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STANDARD VALUES *in* NUTRITION *and* METABOLISM

Being the second fascicle of a Handbook of Biological Data

EDITED BY

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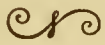

Prepared under the Direction of the Committee
on the Handbook of Biological Data
AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES
THE NATIONAL RESEARCH COUNCIL

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Foreword

Five years ago the National Academy of Sciences-National Research Council contracted with the Wright Air Development Center, United States Air Force, to gather and compile for publication the more basic established data in the various fields of biological science. The present work, issued in August, 1954, under joint sponsorship of the Air Force, Army, Navy, and Atomic Energy Commission as Wright Air Development Center Technical Report 52-301, is the second fascicle* resulting from the project.

Direction of the work was entrusted to the Committee on the Handbook of Biological Data, an organ of the American Institute of Biological Sciences. The Institute is affiliated with the National Research Council as a unit in the Council's Division of Biology and Agriculture. Membership of the Committee is representative of major fields in plant and animal biology.

Seeking highest degree of authoritativeness for the work, the Committee recognized that specialists in a field from which a table is drawn can best exercise the critical judgment necessary to evaluate and select data for an authoritative table. The specialist can best identify those data born of most acceptable methods of measurement and those having greatest likelihood, or actual history, of reproducibility in competent hands. The Committee accordingly prescribed that in selection and review of data broadest collaboration be sought among investigators in nutrition, metabolism, and related fields.

This monograph is the product of contributions of more than 800 specialists in these fields in this country and abroad. Its 160 tables, as originally compiled, were subjected to extensive review by experts in the respective subjects. By this procedure it has been possible to strip from the tables most of the controversial or questionable or borderline material, leaving for final presentation to the user only what is presently accepted as fact by those who are competent to judge. The 223 pages of tables and 16 pages of diagrams contain many thousands of items of authoritative data--mostly quantitative, but with important non-numerical exceptions. The task of culling and condensing the mass of data on hand to conform with time and space limitations has been gigantic. It is planned that much that has been so elimi - nated will be published in subsequent fascicles or in the final Handbook of Biological Data.

Acknowledgment is made, on behalf of the Committee, to Wright Air Development Center, Office of the Surgeon General of the Army, Office of Naval Research, and Division of Biology and Medicine, Atomic Energy Commission, for the foresight and scientific judgment inherent in the commission to prepare this tabular monograph; to the biologists of this and other countries whose generous devotion of time as contributors and reviewers has made possible completion of the work as it stands; and to many others, unlisted, who have given the Committee solicited advice. Acknowledgment is also made to present and former members of the Handbook Staff for their loyalty and devotion to a most tedious and exacting job.

*The first, "Standard Values in Blood", was published in 1952. Others in progress deal with the fields of growth and reproduction, animal and plant physiology, biochemical composition, and toxicology. An abridged Handbook of Biological Data containing tabular information drawn from all areas of biological science is also in preparation.

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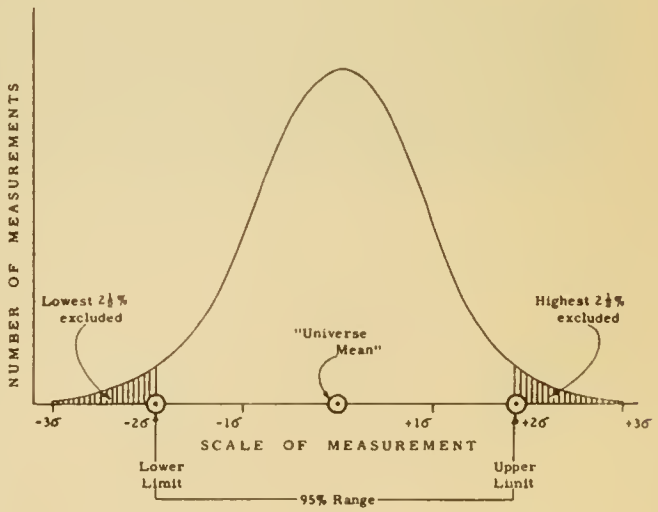
Introduction

This volume presents tabular data and certain charts and graphs in the general field of nutrition and metabolism. Both plant and animal forms are included. The guiding principle in selecting material has been that it be of basic importance in its general field; ready availability elsewhere has not been regarded as a reason for excluding it.

Some material of fundamental importance has had to be omitted, either because efforts to secure the needed data have not succeeded, or because time has not permitted the necessary steps for getting available data into print. Inability to publish material that a contributor may have spent many hours in compiling is cause for the deepest regret. Such unused material will, it is hoped, be the source of valuable additional tables when this volume is revised.

In the preparation of material in tabular form the chief objective has been clarity of presentation. Where the subject matter of a table has been considered to be inherently difficult for the non-specialist -- the beginning student in the subject or the specialist in another field -- effort has been made, in explanatory headnotes and footnotes, to resolve for the reader some of the difficulty. Footnotes have also been used in many instances for information originally within the table itself where simplification of the structure of the table could be achieved by withdrawal of the information into the footnotes.

In each instance where a numerical value is given for a variable, the value is the mean (or adjusted mean) of a group of measured values. Where possible to obtain, each such value is followed by an estimate of the lower and upper limits of the 95% range. The 95% range has been selected in preference to the standard deviation as better suited to the needs of the reader who is not a specialist in the field from which a value has been drawn. The 95% range is a direct representation of the ordinary* range of variation, to be had only by further calculation if the standard deviation alone is available. The latter has the disadvantage of not being readily available in many instances and of giving biased limits for the 95% range when a variable has a skewed distribution. The statistically-minded reader who might wish to make further calculations from values in these tables will not care to proceed without information on comparability and number of measurements. Unfortunately space does not permit including here such collateral information, but the bibliographic references will lead to the original data where it should be found.



The 95% range may be estimated in several ways, the method depending on the information available. The types of estimate most commonly encountered are listed below. The letter designations (a, b, c, d) will be found as identifying superscripts opposite ranges given in the tables. (For details of these and other estimates see texts on statistical methods.)

*To the clinician, equivalent, with reservations, to "normal and borderline".

Range data as commonly encountered, including estimates of the 95% range, represent a mixture of the variability existing between individuals and the variability existing within individuals.

(a) By the method of greatest accuracy, the 95% range is obtained by fitting a recognized type of frequency curve to a group of measured values and excluding the extreme 2.5% of area under the curve at each end. (See sketch on preceding page). Estimate is made by this procedure only when the group of values is relatively large.

(b) By a less accurate method, the 95% range is estimated by a simple statistical calculation, assuming a normal distribution and using the standard deviation. This estimate is used when the group of values is too small for curve fitting, as is usually the case.

(c) A third and still less accurate procedure for estimate of the 95% range is simply to take as range limits the highest value and lowest value of the reported sample group of measurements. It underestimates the 95% range for small samples (3 or 4 values) and overestimates for larger sample sizes, but may be used in preference to the preceding method when the sample shows convincing evidence that the variable is asymmetrical in distribution.

(d) The upper and lower limits of the ordinary range of variation, as estimated by an investigator experienced in measuring the quantity in question and based solely on general experience, constitute still another estimate of the 95% range. The trustworthiness of limits so placed should not be underestimated.

In many instances range data have not been available. In other instances an estimate of the 95% range is given, but information on the manner of estimate is lacking. Effort to assemble both types of missing information is continuing.

The data in each table are in the judgment of the contributors and reviewers established fact and free of questionable material, and represent the consensus of expert judgment and experience in the special field from which the table was drawn. It is recognized, however, that all data are subject to continuing revision as investigators improve techniques and make more measurements. The reader is warned against attributing significance to small differences from species to species. He is invited to submit any values or ranges he feels should be given consideration, and is particularly invited to add to the coverage of animal and plant forms.

TABLES

1. NUTRIENTS: THE CHEMICAL ELEMENTS

If an organism cannot achieve typical growth, health, or reproduction in the absence of an element, the element is listed as R (or r). If addition of an element not required improves growth, health or reproduction, the element is listed as s. Accumulation in the tissues of an organism is not, alone, taken as sufficient evidence of requirement. Characterizations are subject to change with further study and increasing purity of materials. In particular r may become R, and ∄ may become R or r.

R = Required by all forms studied; ∄ = Not required by any forms studied; r = Required by one or more species or strains; "u=" = Utilized as effectively, replaces wholly or is interchangeable with another element for one or more species or strains; u< = Can partially replace or spare another element for one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; a = Accumulated in the tissues of one or more forms; c = Commonly present in the food of some forms and in the tissues at similar concentrations but requirement is uncertain.

	Groups of Organisms / Nutrient Element	Plants						Animals			
									Invertebrates		
		Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phytoflagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Aluminum	r,s,a	∄	∄	∄,u<[4]	∄	∄	∄	∄		∄
2	Arsenic	∄	∄	∄	∄	∄	∄	∄	∄	a	∄
3	Boron	R	∄,s	∄	r	r	r?	∄	∄	∄	∄
4	Bromine	∄	∄	∄	∄	∄,a	∄	∄	∄	r?,[5]a?	∄
5	Calcium	R	r,s,a	r,u=[6]	r,s	R	r	R	r,c	r	R
6	Carbon[7]	R	R	R	R	R	R	R	R	R	R
7	Chlorine	r,s	∄	∄	∄	a	∄	∄	r,c	r	R
8	Chromium	∄	∄	∄	u=[8]	∄	∄	∄	∄		∄
9	Cobalt	r	r	u=[6]	r	r	r	r	r?,s?		r
10	Copper	R	R	r	r,u<[4]	r		r	r,c	r	r
11	Fluorine	∄,a	∄	∄	∄	∄	∄	∄	∄	a	∄,s
12	Gallium	r	r,s	∄	∄	∄	∄	∄	∄	∄	∄
13	Hydrogen[7]	R	R	R	R	R	R	R	R	R	R
14	Iodine	∄,s	∄	∄,s	∄,s	∄,a	∄	∄	∄	r?,a	R
15	Iron	R	R	R	r,u<[4]	R	R	R	R	r	R

/1/ Spermatophytes (the intact plant). /2/ = Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including the colorless phytoflagellates. /4/ u< Mn or Cr for Aerobacter aerogenes. /5/ Occurs in scleroprotein of certain corals as di-bromotyrosine. /6/ u= Ca in yeast cocarboxylase. /7/ Universal constituents of protoplasm. /8/ u= Mn for Aerobacter aerogenes.

1. NUTRIENTS: THE CHEMICAL ELEMENTS (Concluded)

If an organism cannot achieve typical growth, health, or reproduction in the absence of an element, the element is listed as R (or r). If addition of an element not required improves growth, health or reproduction, the element is listed as s. Accumulation in the tissues of an organism is not, alone, taken as sufficient evidence of requirement. Characterizations are subject to change with further study and increasing purity of materials. In particular r may become R, and ∄ may become R or r.

R = Required by all forms studied; ∄ = Not required by any forms studied; r = Required by one or more species or strains; "u= " = Utilized as effectively, replaces wholly or is interchangeable with another element for one or more species or strains; u< = Can partially replace or spare another element for one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; a = Accumulated in the tissues of one or more forms; c = Commonly present in the food of some forms and in the tissues at similar concentrations but requirement is uncertain.

	Groups of Organisms / Nutrient Element	Plants						Animals			
									Invertebrates		
		Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phytoflagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
16	Magnesium	R	R	R	r	R	R	R	R	R	R
17	Manganese	R	r,s	r,u=[6]	r,u=	r	r	r	r,c,a	r[9]	R
18	Molybdenum	R,a	R,[10]s	r	r[10]	r[10]	∄	∄			r[11]
19	Nitrogen[7]	R	R	R	R	R	R	R	R	R	R
20	Oxygen[7]	R	R	R	R	R	R	R	R	R	R
21	Phosphorus[7]	R	R	R	R	R	R	R	R	R	R
22	Potassium	R	R	r	r	R,a	R	R	r,c,a	R	R
23	Rubidium	∄	∄	∄	u=[12]	∄	∄	∄	∄		∄
24	Selenium	∄,a	∄	∄	∄	∄	∄	∄	∄		∄
25	Silicon	r	∄	∄	∄	∄	r	r	∄	r	∄
26	Sodium	r?,s,a	∄	∄	r	r,a	∄	r	r?,c		R
27	Strontium	∄	∄	∄	u=[13]	∄,u=	∄	∄	∄		∄
28	Sulfur[7]	R	R	R	R	R	R	R	R	R	R
29	Tungsten	∄	s	∄	∄	∄	∄	∄	∄		∄
30	Vanadium	∄	∄,s	∄	u<[14]	r	∄	∄,s?	∄	r[15]	∄
31	Zinc	R	R	r	r,u=	r	r	r	r	r?,a	R

/1/ Spermatophytes (the intact plant). /2/ = Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including the colorless phytoflagellates. /6/ u= Ca in yeast cocarboxylase. /7/ Universal constituents of protoplasm. /9/ In blood respiratory pigment of Pinna squamosa (mollusk). /10/ R for NO_3^- utilization by some fungi and some algae; R for N_2 fixation by some bacteria and algae. /11/ "Xanthine oxidase factor." /12/ u= Ca by some. /13/ u= Ca by Azotobacter. /14/ u< Mo in N_2 fixation. /15/ In blood pigment of certain tunicates (Chordata).

2. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: AMINO ACIDS, PEPTIDES, PROTEINS

Requirement depends on inability of an organism to synthesize a needed molecular structure. Amino acids not known to be required from the environment by any organism, e. g. hydroxyproline, iodogorgoic, norleucine, ornithine, thyroxine are omitted. No distinction between dextro- and laevo-isomers is made although they are not, in many cases, nutritionally equivalent. It is noteworthy that in one concentration an amino-acid may support good growth, in another concentration inhibit or be toxic. When requirement and utilization are noted together it is to be understood that at least one member of a group requires the amino-acid specifically, other members do not require but utilize it as a general nitrogen source, for energy or synthesis of other compounds. Only needs of intact organisms are considered.

R = Required by all forms studied; ∄ = Not required by any form studied; r = Required by one or more species or strains; rm = Required by one or more mutants; U = Utilized as a source of nitrogen and/or carbon by all forms studied although not a specific requirement for all; u = Utilized by one or more species or strains as a source of nitrogen and/or carbon although not a specific requirement; "u=" = Replaces effectively one or more other amino-acids, one of the interchangeable series being required in the diet; ∦ = Not utilized by one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; * = Serves as complete nitrogen source for one or more species or strains; **=Serves as simplest complete nitrogen source for one or more species or strains.

Nutrient \ Groups of Organisms	Plants						Animals			
								Invertebrates		
	Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1 Organic N (per se)	∄,u*	r,rm,u*[4]	r,rm,u*[4]	r,u*[4]	∄,u*	r,u*	r,U*	R,U*	R	R,U*
2 Proteins (per se)	∄	∄,u*	∄,u*	∄,u*	∄	u	r[5],u*	∄[6],s,U*	U	∄[6],s,U*
3 Polypeptides[7], peptones	∄,u*	∄,u*	∄,u*	r,u*[8]	∄,u*	u=[9],u*	r,u*	∄		∄,U
4 Amino acids	∄,u*[10]	r,rm,u*	rm,u*[11]	r[12],rm,u*	∄,u*[13]	r,u=[9],u*[14]	r[15],u*	R,U**		R,U**
Amino Acids										
5 Alanine	∄,u*	u*,u=[16]	u*	r,u*	∄,u*	∄,u*	u	r[17],u=		∄,U
6 Arginine	∄,u*	rm,u*	rm,u*	r,rm,u*	∄,u*	∄,u*	r[18],s,u	r[17]		r[19],U
7 Aspartic acid[20]	∄,u*	u*,u=[16]	u*	r,u*	∄,u*	r,u*	u,s	r[17],u=		∄,U
8 Citrulline	∄	rm,u*		r,u*	∄		u	r,u=[21]		∄,u=[21],U
9 Cysteine	∄,u*	rm,u*	u*	r,u*	∄,u*		u	r,u=		∄,U
10 Cystine	∄,u*	rm,u*	u*	r,rm,u*	∄		u	r[17],u=		∄,U
11 Glutamic acid[20]	∄,u*	rm,u=[16],u*	u*	r,u*	∄,u*	∄,u*	u,s	r[17]		s,U
12 Glycine	∄,u*	rm,u*	u*	r,u*	∄,u*	∄,u*	r[18],u	r,		r[22],U
13 Histidine	∄,u*	r,rm,u*	r,u*	r,rm,u*	∄,u*	r,u*	r[18],s,u	r[17]		R[23]
14 Isoleucine	∄,u*	rm,u*	rm,u*	r,rm,u*	∄,u*		r[18],u	r[17]		R[23]
15 Leucine	∄,u*	rm,u*	rm,u*	r,rm,u*	∄,∦	∄,u*	r[18],u	r[17],u=		R[23]

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including colorless phytoflagellates. /4/ Most grow better on organic than on inorganic N. /5/ Many require living prey. /6/ On assumption that suitable amino acid combinations can replace complete proteins. /7/ See strepogenin (table 6). /8/ Entire peptides, polypeptides, low molecular weight proteins directly assimilated by some. /9/ Either 3 or 4 required by photoautotrophs growing in dark. /10/ Several tested intact plants grow on single amino acids as sole N-source. Growth attained on some amino acids is superior to that achieved with NH_4^+, NO_3^-, as N-source, on other amino acids inferior. Some plants grow less well on amino acids than on inorganic N. Marked differences exist between species with respect to amino acid utilization. Some amino acids are toxic, under the experimental conditions used, for some plants. Among plants tested are: tomato, tobacco, clover, peas, orchid embryos, young orchid. (For Footnotes 11-25 see following page.)

2. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: AMINO ACIDS, PEPTIDES, PROTEINS (Concluded)

Requirement depends on inability of an organism to synthesize a needed molecular structure. Amino acids not known to be required from the environment by any organism, e. g. hydroxyproline, iodogorgoic, norleucine, ornithine, thyroxine are omitted. No distinction between dextro- and laevo-isomers is made although they are not, in many cases, nutritionally equivalent. It is noteworthy that in one concentration an amino-acid may support good growth, in another concentration inhibit or be toxic. When requirement and utilization are noted together it is to be understood that at least one member of a group requires the amino-acid specifically, other members do not require but utilize it as a general nitrogen source, for energy or synthesis of other compounds. Only needs of intact organisms are considered.

R = Required by all forms studied; ∄ = Not required by any form studied; r = Required by one or more species or strains; rm = Required by one or more mutants; U = Utilized as a source of nitrogen and/or carbon by all forms studied although not a specific requirement for all; u = Utilized by one or more species or strains as a source of nitrogen and/or carbon although not a specific requirement;"u=" =Replaces effectively one or more other amino-acids, one of the interchangeable series being required in the diet; ∄ = Not utilized by one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; * = Serves as complete nitrogen source for one or more species or strains; **=Serves as simplest complete nitrogen source for one or more species or strains.

Nutrient \ Groups of Organisms	Plants						Animals			
								Invertebrates		
	Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
16 Lysine	∄,u*	rm,u*	u*	r,rm,u*	∄,∄	∄,u*	r^{18},u	r^{17}		R^{23}
17 Methionine	∄,u*	r,rm,u*	r,u*	r,rm,u*	∄,∄	r	r^{18},u	r^{17}		$R^{23,24}$
18 Phenylalanine	∄,u*	rm,u*	rm,u*	r,rm,u*	∄,∄	∄,u*	r^{18},u	r^{17},u=		$R^{23,24}$
19 Proline	∄,u*	rm,u*	u*	r,u*	∄,∄	∄,u*	r^{18},u	r^{17}		∄,U
20 Serine	∄,u*	rm,u*	u*	r,u*	∄,∄	∄,u*	r^{18},s,u	r^{17}		∄,U
21 Threonine	∄,u*	rm,u*	u*	r,u*	∄,∄		r^{18},u	r^{17},u=		R^{23}
22 Tryptophan[25]	∄,u*	r,rm,u*	u*	r,rm,u*	∄,u*	∄,∄	r^{18},u	r^{17},s,u=		R^{23}
23 Tyrosine	∄,u*	rm,u*	u*	r,rm,u*		∄,∄	r^{18},u	u=		∄,U
24 Valine	∄,u*	rm,u*	u*	r,rm,u*	∄,u*	∄,u*	r^{18},s,u	r^{17},u=		R^{23}

/11/ Amino acid mixtures superior to NH_4^+ as N-source for some, e.g. Saccharomyces cerevisiae, S. carlsbergensis. /12/ Wide differences of requirement exist between species, species mutants,e.g. Leuconostoc mesenteroides R all the amino acids listed except 5 and 8, Lactobacillus bifidus R only 9. /13/ Based mainly on Chlorella pyrenoidosa. /14/ Marked differences between various species and varieties with respect to amino acid utilization; environmental conditions sharply modify. /15/ Best known requirements are those of Tetrahymena, Trichomonas foetus, Herpetomonas culicidarum, Glaucoma scintillans. /16/ Interchangeable for a Neurospora mutant. /17/ Basic common requirements of Tribolium confusum,Drosophila melanogaster, Aedes aegypti, Blattella germanica are covered by 6, 10, 13-18, 21, 22, 24. For A. aegypti 18 or 21 + 22 + 24 may be eliminated from diet. For B. germanica 5, 7, 11 u= , but one at least must be present; male also R 19, 20; 9, 10, 17 u= ,and may be replaced by homocysteine,cysteic acid, isethionic acid, inorganic SO_4; 15, 24 u= ; 18-23 u= ,and may be replaced by 3, 4-dihydroxyphenylalanine, phenylacetic, 2, 4-dihydroxybenzoic, shikimic,orsellinic acids. /18/ R by Tetrahymena geleii,Glaucoma scintillans,Trichomonas foetus, Herpetomonas culicidarum are 6, 13-18, 22, 24;in addition G. scintillans,T. foetus R 12, 19-21 and H. culicidarum R 23. T. geleii needs no other carbon source. /19/ R by rat, chicken. /20/ Asparagine (amide of 7) and glutamine (amide of 11) U by at least some in all the groups listed and R by some. /21/ 6, 8 interchangeable for some. /22/ R by chick for rapid growth. /23/ R by man, mouse, rat, chicken. 13 not required to maintain nitrogen balance in adult human. /24/ Amount of methionine R by man depends on amount of cystine in diet. Amount of phenylalanine R by man depends on amount of tyrosine in diet. /25/ Precursor of niacin which it spares for some organisms.

3. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: LIPIDS

Compounds listed as R or r are required for some detail of molecular structure that the organism cannot adequately synthesize.

∄ = Not required by any form studied; r = Required by one or more species or strains; rm = Required by one or more mutants; u = Utilized by one or more species or strains; "u= " = Utilized as effectively as a related substance by one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; i = Inhibits growth or other processes for one or more species or strains.

Nutrient Compound \ Groups of Organisms	Plants						Animals			
								Invertebrates		
	Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
Steroids										
1 Cholesterol	∄	r[4]	u	u	∄	∄	r[5]	R		∄
2 7-Dehydrocholesterol	∄	∄	∄	∄	∄	∄	∄,u=[6]	u=		u[7]
3 Ergostanol acetate	∄	∄	∄	∄	∄	∄	∄,u=[6]			s[8]
4 Ergosterol	∄	∄	u,s	∄,	∄	∄	R,u=[6]	u=		u[9]
5 Stigmasterol	∄	∄	∄	∄	∄	∄	r[10]	u=		∄,s
Long Chain Fatty Acids and Their Derivatives										
6 Arachidonic acid[11]	∄		∄		∄	∄		s		r,u=
7 Linoleic acid[11]	∄	rm	∄	s,i	∄	∄	u=[12]	r		r,u=
8 Linolenic acid[11]	∄		∄		∄	∄		u=		r,u=
9 Oleic acid	∄	rm,s	∄	s,i	∄	∄	s,i	r		∄
10 "Tween 80, 85"[13]	∄	∄	∄	∄,s,i	∄	∄	∄,s	∄		∄
11 "Myrj G 2144"[13]	∄	∄	∄	∄	∄	∄	∄,s	∄		∄
Phospholipids										
12 Lecithin[14]	∄	∄	∄	∄	∄	∄	s	u=,s		∄

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including the colorless phytoflagellates. /4/ r by Labyrinthula vitellina (var. pacifica only). /5/ For several individual insect species various steroids u= . /6/ u= in place of 1 by Trichomonas. /7/ Precursor of vitamin D_3. /8/ Relieves "stiffness syndrome" of guinea pig. /9/ Precursor of vitamin D_2. /10/ R by Paramecium aurelia; a requirement of P. aurelia for Sitosterol has also been noted. /11/ The "essential fatty acids" of vertebrates. /12/ u= a required ether soluble factor of blood serum by Trichomonas. /13/ Synthetic detergents; 10 = sorbitan esters of fatty acids, e. g. oleic; 11 = polyoxalkalene derivative of oleic acid. /14/ Ill-defined complex mixture of di-esters of α-glycerophosphoryl choline with many unsaturated fatty acids and other substances, especially amino acids.

4. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: VITAMINS AND RELATED COMPOUNDS

It is probable that many of these compounds participate, indispensably, in the metabolic activities of all living substance and are, in this sense, universally "required." This tabulation, however, is limited to a consideration of presently known requirement or non-requirement from the external environment or in the diet. Excluded is consideration of those instances in which metabolically essential compounds are provided to an organism by associated microorganisms which synthesize them, e.g. by the intestinal flora of mammals. The special needs of excised tissues or cells, living apart from the intact organism, are not considered. Environmental conditions may strongly modify the need for and/or the utilization of vitamins and growth factors. The characterization, "not required" (∄), derives either from experimental proof gathered from the forms studied or from the current absence of data indicating requirement by the forms studied.

R = Required by all forms studied; ∄ = Not required by any form studied; r = Required by one or more species or strains, (OMSS); rm = Required by one or more mutants; u = Utilized by OMSS; "u= " = Utilized as effectively as the related compound(s) or vitamin by OMSS; u> = Utilized more effectively than the related compound(s) or vitamin and considered to be required by OMSS; u< = Utilized less effectively than the related vitamin by OMSS; u=< = Utilized as well or less effectively than the related vitamin by OMSS; ∉ = Not utilized in place of the related vitamin by OMSS; s = Stimulates growth or other processes for OMSS; i = Inhibits growth or other processes for OMSS.

	Compound	Related Compounds[1]	Plants: Higher Green Plants[2]	Plants: Fungi	Plants: Yeasts	Plants: Bacteria	Plants: Algae	Plants: Green Phytoflagellates[3]	Animals: Protozoa[4]	Animals: Invertebrates: Insects	Animals: Invertebrates: Other	Animals: Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
	Vitamins[5]											
1	Vitamin A	(inc)A_1,A_2,A_3,(rel) 21A	∄,s	∄	∄	∄	∄	∄	r?	∄		R
2	Ascorbic acid		∄,s	∄,s	∄,s	∄,s	r?,s	∄	r,s	∄		r
3	Biotin	(rel)20A,24A,30A,34A	∄	r,rm,s	r,s	r	r	∄	r,s	r		r
4	Choline group[6]		∄,s	r,rm	∄	r	∄	∄	∄	r		r
5	Cobalamin[7]	(rel)39A,45A	∄,s	∄	∄	r[8]	r	r	r	r?,s		r
6	Vitamin D[9]	(inc)D_2,D_3,D_4 etc.	∄	∄	∄	∄	∄	∄	∄	∄		R[9]
7	Vitamin E	(inc)α,β,γ,δ-Tocopherols	∄	∄	∄	∄	∄	∄	∄	∄,s		r
8	Inositol[10]	= meso-Inositol	∄,s	r,rm,s	r,s	r?,s	∄	∄	∄	r		r?
9	Vitamin K	= K_1,K_2	∄	∄	∄	r	∄	∄	∄	r		r
10	Nicotinic acid	(rel)11A,25A,48A	∄,s?	r,rm,s	r	r,s	∄	∄	r	r		r
11	Nicotinamide	(rel)10A	∄,s?	r,rm,s	u=	r,u=,s	∄	∄	u=	u=		u=
12	Pantothenic acid	(rel)19A,22A,31A,35A	∄,s	r,rm,s	r	r,s	r	∄	r	r		R
13	Pteroylglutamic acid[11]	(rel)27A,40A,44A,49A	∄	∄	∄	r[12]	∄	∄	r	r		R
14	Pyridoxal[13]	(rel)15A,16A,41A,42A	∄	u=	u=,s	r,u>	∄	∄	u=	u=		u=
15	Pyridoxamine[13]	(rel)14A,16A,41A,42A	∄	u=	u=,s	r,u>	∄	∄	u=	u=		u=
16	Pyridoxine[13]	(rel)14A,15A,41A,42A	∄,s	r,rm,s	r,s	r,s	∄,s	∄	r	r		R
17	Riboflavine		∄	rm	∄	r,s	∄	∄	r	r		R
18	Thiamine	(rel)26A,32A;(co)43A+47A	∄,s	r,rm,s,i[14]	r,i[15]	r,s	r	r	r	r		R
	Compounds Chemically Related to Vitamins[5]											
19	β-Alanine	(po)12A	∄	rm,u=	∄,u=	∄,u=	∄	∄	∄,∉	∄		∄,s
20	Biocytin	(rel)3A	∄	∄	∄	u	∄	∄	∄	∄		∄
21	β-Carotene[16]	(pre)1A	∄	∄	∄	∄	∄	∄	∄	∄	r?[17]	∄,u<
22	Coenzyme A	(co)12A+ADP+PO_4	∄	∄	∄,s	r,u>	∄	∄	∄	∄		∄,u<
23	5,6-Dimethylbenzimidazole	(po)5A	∄	∄	∄	∄	∄	∄,u<	∄	∄		∄,u<
24	Desthiobiotin	(rel)3A,30A,34A	∄	∄	∄	∄,u<	∄	∄	∄	∄		∄
25	DPN[18]	(co)10A+ribose PO_4	∄	r,u>,s	∄,u=	r,u=	∄	∄	∄	∄,u=<		∄,u=<

/1/ (co) = composed of; (po) = part of; (pre) = precursor of; (rel) = related to; (inc) = Includes. /2/ Spermatophytes (the intact plant). /3/ Green phytoflagellates, chrysomonads, dinoflagellates. /4/ Including the colorless phytoflagellates. /5/ Vitamin = an organic compound, other than an amino-acid, carbohydrate or essential fatty acid, required in the diet by at least one vertebrate animal. /6/ Includes: choline, betaine and other methyl donors, e.g., mono- and tri-ethyl choline, ethanolamine, diethylethanolamine, mono- and di-ethylamino- ethanol, di- and tri-ethyl-choline. /7/ Generic term including cyanocobalamin, hydroxocobalamin, vitamins B_{12}, B_{12a}, B_{12b}. /8/ For some, thymine desoxyriboside, hypoxanthine, adenine, guanine may substitute in certain media. /9/ D_2 active for mammals only; D_3 active for all and R by chicken. /10/ Of doubtful status as a vitamin. /11/ = Folic acid, folacin. /12/ For one or more, pteroic acid (q.v. 40A) or thymine + thymidine will substitute. /13/ Member of the pyridoxine group (Vitamin B_6). /14/ Inhibits growth of Rhizopus nigricans. /15/ Inhibits growth of strains of Saccharomyces cerevisiae. /16/ And other carotenoid precursors of vitamin A. /17/ R? by certain crustacea whose eyes contain vitamin A. /18/ Diphosphopyridine nucleotide.

4. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: VITAMINS AND RELATED COMPOUNDS (Concluded)

It is probable that many of these compounds participate, indispensably, in the metabolic activities of all living substance and are, in this sense, universally "required." This tabulation, however, is limited to a consideration of presently known requirement or non-requirement from the external environment or in the diet. Excluded is consideration of those instances in which metabolically essential compounds are provided to an organism by associated microorganisms which synthesize them, e.g. by the intestinal flora of mammals. The special needs of excised tissues or cells, living apart from the intact organism, are not considered. Environmental conditions may strongly modify the need for and/or the utilization of vitamins and growth factors. The characterization, "not required" (✗), derives either from experimental proof gathered from the forms studied or from the current absence of data indicating requirement by the forms studied.

R = Required by all forms studied; ✗ = Not required by any form studied; r = Required by one or more species or strains, (OMSS); rm = Required by one or more mutants; u = Utilized by OMSS; "u= " = Utilized as effectively as the related compound(s) or vitamin by OMSS; u> = Utilized more effectively than the related compound(s) or vitamin and considered to be required by OMSS; u< = Utilized less effectively than the related vitamin by OMSS; u=< = Utilized as well or less effectively than the related vitamin by OMSS; ✗ = Not utilized in place of the related vitamin by OMSS; s = Stimulates growth or other processes for OMSS; i = Inhibits growth or other processes for OMSS.

	Compound (A)	Related Compounds[1] (B)	Plants: Higher Green Plants[2] (C)	Fungi (D)	Yeasts (E)	Bacteria (F)	Algae (G)	Green Phytoflagellates[3] (H)	Animals: Protozoa[4] (I)	Invertebrates: Insects (J)	Invertebrates: Other (K)	Vertebrates (L)
			Compounds Chemically Related to Vitamins[5] Concluded									
26	Diphosphothiamine	(co)18A+PO4	✗	✗,u<	✗,u=	r,u>	✗	✗,u=	✗,u=	✗		✗,u=
27	Folic acid conjugates[19]	(co)13A+glutamate	✗	✗	✗	✗,u=	✗	✗	✗,u=	✗,u=		✗,u=
28	Folinic acid[20]	(rel)13A	✗	✗	✗	r	✗	✗	✗,u=	✗		✗,u<
29	Hesperidin[21]	(po) "Vitamin P" series	✗,s	✗	✗	✗	✗	✗	✗	✗		✗,s
30	O-Heterobiotin	(rel)3A,24A,34A	✗	✗	✗	✗,u<,✗	✗	✗	✗	✗		✗
31	L.B. factor[22]	(rel)12A	✗	✗	✗	r,u>	✗	✗	✗	✗		✗
32	Lipothiamide	(co)18A+lipoic acid	✗	✗	✗	✗	✗	✗	✗	✗		✗,u=
33	Lyxoflavin	(rel)17A	✗	✗	✗,	✗,u<	✗	✗	✗	✗		✗,s,u<
34	Oxybiotin	(rel)3A,24A,30A	✗	✗	✗	✗,u<	✗	✗	✗	✗		✗
35	"Pantothenic acid conjugate"	(co)12A+adenine+glutamate	✗	✗	✗	r?,u>	✗	✗	✗	✗		✗
36	Pantoic acid	(po)12A	✗	✗	✗,u	✗,u	✗	✗	✗	✗		✗,✗
37	Para-aminobenzoic acid	(po)40A	✗	r,rm	r	r	✗	✗	r	✗		✗,s
38	Pimelic acid	(rel po)3A	✗	✗,s	✗	✗,u=<	✗	✗	✗,u<	✗		✗,✗
39	Pseudovitamin B12	(rel)5A	✗	✗	✗	✗,u=	✗	✗,u=	✗	✗		✗,✗
40	Pteroic acid	(po)13A	✗	✗	✗	✗,u<	✗	✗	✗,u=,✗	✗		✗,✗
41	Pyridoxal-PO4	(rel)14A	✗	✗,u=	✗,u	r,u>	✗	✗	✗,u=	✗,u=		✗,u=
42	Pyridoxamine-PO4	(rel)15A	✗	✗,u=	✗,u	r,u>	✗	✗	✗,u=	✗,u=		✗,u=
43	Pyrimidine[23,24]	(po)18A	✗	r,rm,u[23,24]	r,s[23,24]	r,u[23,24]	r[23,24]	r,u[23,24]	r,u[23,24]	✗		✗,✗
44	Rhizopterin	(rel po)13A	✗	✗	✗	✗,u=	✗	✗	✗	✗		✗,✗
45	α - Ribazole	(po)5A	✗	✗	✗	✗	✗	✗,u<	✗	✗		✗,s
46	Rutin[21]	(po) "Vitamin P" series	✗	✗	✗	✗	✗	✗	✗	✗		✗,s
47	Thiazole[24,25]	(po)18A	✗	r,rm,u[24,25]	r,s[24,25]	r,u[24,25]	r[24,25]	r,u[24,25]	r,u[24,25]	✗		✗
48	TPN	(co)10A+ribose+PO4	✗	r,u>,s	✗,u=	✗,u=	✗	✗	✗	✗		✗,u=
49	Xanthopterin	(rel po)13A	✗	✗	✗	✗,u<	✗	✗	✗	✗		r?[26],u>[26],s

/1/ (co) = composed of; (po) = part of; (pre) = precursor of; (rel) = related to; (inc) = Includes. /2/ Spermatophytes (the intact plant). /3/ Green Phytoflagellates, chrysomonads, dinoflagellates. /4/ Including the colorless phytoflagellates. /5/ Vitamin = an organic compound, other than an amino-acid, carbohydrate or essential fatty acid, required in the diet by at least one vertebrate animal. /19/ Di-, tri- and hepta-glutamates of pteroylglutamic acid. /20/ = The citrovorum factor, R by Leuconostoc citrovorum. /21/ 29, 46 and citrin = "vitamin P" series. /22/ Lactobacillus bulgaricus factor which = pantetheine, pantethine,(N-(pantothenyl) β-aminoethanol and corresponding di-sulfide?). /23/ Thiamine or pyrimidine moiety, (thiazole moiety is synthesized). /24/ Thiamine or pyrimidine + thiamine moieties, (pyrimidine and thiazole moieties combined to give thiamine). /25/ Thiamine or thiazole moiety, (pyrimidine moiety is synthesized). /26/ More active than pteroylglutamic (folic) acid in relieving anemia of Chinook salmon, (fish).

5. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: PURINES, PYRIMIDINES

Purine and pyrimidine compounds are essential components of the nucleic acids. Inability to synthesize these compounds makes it necessary for many organisms to obtain them from an environmental or dietary source for nucleic acid synthesis and synthesis of other essential purine and pyrimidine compounds. For some organisms the requirement is for a specific compound(s), for others any one of an interchangeable series satisfies the need. The pyrimidines: cytosine, thymine, uracil, and the purines: adenine and guanine combine with ribose or desoxyribose to form nucleosides (cytidine, thymidine, uridine, adenosine, guanosine) which with H_3PO_4 form nucleotides: cytidylic, uridylic, adenylic and guanylic acids. Nucleotides combine to form polynucleotides. The nucleic acids are specific tetranucleotides. The characterization "not required" derives either from direct experimental evidence or absence of data presently indicating requirement.

∄ = Not required by any form studied; r = Required by one or more species or strains; rm = Required by one or more mutants; u = Utilized by one or more species or strains; ∦ = Not utilized by one or more species or strains; "u= " = Utilized as effectively as (or interchangeably with) one or more related compounds, the presence of at least one of the series being required by one or more species or strains. u< = Partially replaces or spares one or more required or interchangeably required compounds for one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; i = Inhibits growth or other processes for one or more species or strains.

	Groups of Organisms / Compound	Plants						Animals			
									Invertebrates		
		Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagel-lates[2]	Protozoa[3]	Insects	Other	Verte-brates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Pyrimidine compounds	∄	r,rm,s	r,s	r,s,u[4]	r	r	r,[5]s	r		∄,s
2	Purine compounds	∄	rm,s,u[4]	s,u[4]	r,s,u[4]	∄	∄	r,[5]s	r		∄,s
	Compounds Containing Pyrimidine Ring[6]										
3	Cytidine	∄	∄,rm,s	∄	u=[7]	∄	∄	u=,i	∄		∄
4	Cytidylic acid	∄	∄,rm,s[8]	∄	u=[7]	∄	∄	u=,s	∄		∄
5	Cytosine	∄	rm	∄	u=[9]	∄	∄	r?,∦,[10]i	∄		∄
6	Orotic acid	∄	rm,s[8]	∄	r[11],s	∄	∄	∄,∦[10]	∄		∄,s
7	Pyrimidine[12]	See Table 4									
8	Thymine	∄	∄	∄	u=[13],u<[14]	∄	∄,u<[15]	r?,u<[16]	r		∄,s
9	Thymidine	∄	∄	∄	u<[14]	∄	∄	u<[16]	∄		∄,s
10	Uracil	∄	rm,s[8]	∄	u=[7],s	∄	r?	r,u=[17]	r[18]		∄
11	Uridine	∄	∄,rm,s	∄	u=[7],s	∄	∄	u=	∄		∄
12	Uridylic acid	∄	∄,rm,s[8]	∄	u=[7],s	∄	∄	u=	∄		∄

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including colorless phytoflagellates. /4/ Numerous pyrimidine and purine compounds utilized as nitrogen sources by fungi, yeasts and bacteria which do not require these compounds specifically. /5/ Requirements of Tetrahymena geleii have been most extensively studied. /6/ A 6 atom ring containing 4C and 2N, the latter in the 1 and 3 positions. /7/ At least one required, but interchangeable, for several species e. g. Clostridium tetani, Hemophilus parainfluenzae. /8/ Stimulates mutants of Neurospora. /9/ Lactobacillus arabinosus, Leuconostoc mesenteroides r 5 or 17. (interchangeable). /10/ ∦ by Tetrahymena. /11/ r by Lactobacillus bulgaricus 09. /12/ Pyrimidine moiety of thiamine. /13/ Clostridium tetani r either 13 or 20 (interchangeable). /14/ Spares folic acid for Streptoccocus lactis; 8 + 9 replaces folic acid for S. lactis./15/ Spares, and given with amino-acids,substitutes for para-aminobenzoic and folic acids for Euglena gracilis. /16/ Spares folic acid for Tetrahymena. /17/ For Tetrahymena, 10 or 3, 4, 11 or 12 r. /18/ Drosophila melanogaster r 10 + sucrose, 10 + 13 + 17 or nucleic acid.

5. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: PURINES, PYRIMIDINES (Concluded)

Purine and pyrimidine compounds are essential components of the nucleic acids. Inability to synthesize these compounds makes it necessary for many organisms to obtain them from an environmental or dietary source for nucleic acid synthesis and synthesis of other essential purine and pyrimidine compounds. For some organisms the requirement is for a specific compound(s), for others any one of an interchangeable series satisfies the need. The pyrimidines: cytosine, thymine, uracil, and the purines: adenine and guanine combine with ribose or desoxyribose to form nucleosides (cytidine, thymidine, uridine, adenosine, guanosine) which with H_3PO_4 form nucleotides: cytidylic, uridylic, adenylic and guanylic acids. Nucleotides combine to form polynucleotides. The nucleic acids are specific tetranucleotides. The characterization "not required" derives either from direct experimental evidence or absence of data presently indicating requirement.

∄ = Not required by any form studied; r = Required by one or more species or strains; rm = Required by one or more mutants; u = Utilized by one or more species or strains; ∦ = Not utilized by one or more species or strains; "u= " = Utilized as effectively as (or interchangeably with) one or more related compounds, the presence of at least one of the series being required by one or more species or strains. u< = Partially replaces or spares one or more required or interchangeably required compounds for one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; i = Inhibits growth or other processes for one or more species or strains.

	Groups of Organisms / Compound	Plants						Animals			
									Invertebrates		
		Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagel-lates[2]	Protozoa[3]	Insects	Other	Verte-brates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Compounds Containing Purine Ring[19]										
13	Adenine	∄	rm	r[20]	u=[21]	∄	∄,u<[15]	r?,u<[22]	r[18]		∄,s
14	Adenosine	∄	∄	∄	u=[21]	∄	∄	∄,u<[22]	∄		∄
15	Adenosine triphosphate	∄	∄	∄	u=[21]	∄	∄	∄,s	∄		∄
16	Adenylic acid	∄	∄	∄	u=[21]	∄	∄	r,u<[22]	∄		∄,s
17	Guanine	∄	r,rm,s	∄	u=[9,21],s	∄	s	r[23]	r[18]		∄
18	Guanosine	∄	∄	∄	u=[21]	∄	∄	r?,u=,u<[24],i	∄		∄
19	Guanylic acid	∄	∄	∄	u=[21]	∄	∄	u=,s	∄		∄
20	Hypoxanthine	∄	r,rm	∄	u=[21],s	∄	s	u=,u<[22]	∄		∄
21	Xanthine	∄	∄	∄	u=[20]	∄	∄	r?,[25]∦[10]	∄		∄
22	Others	∄						s[26]			

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including colorless phytoflagellates. /9/ Lactobacillus arabinosus, Leuconostoc mesenteroides r 5 or 17.(interchangeable). /10/ ∦ by Tetrahymena. /15/ Spares, and given with amino-acids, substitutes for para-aminobenzoic and folic acids for Euglena gracilis. /18/ Drosophila melanogaster r 10 + sucrose, 10 + 13 + 17 or nucleic acid. /19/ The purine ring structure = a pyrimidine ring and imidazole ring (3C, 2N) with two carbons in common. /20/ r by Saccharomyces octosporus on certain media. /21/ Items 13 - 21 variously interchangeable for different bacteria, but at least one must be present, e. g. Streptococcus hemolyticus r at least one of 13, 14, 16, 17, 18, 19, 21 (the requirement is relieved by CO_2 in high concentration); 13, 17, 20 or 21 r by Streptococcus lactis; 14 r by B. megaterium for spore germination. /22/ Spares but cannot replace 17, 18, 19 for Tetrahymena. /23/ r by Tetrahymena, replaceable by 18 or 19. /24/ Spares folic acid (as does adenosine) for Herpetomonas culicidarum. /25/ In vitro studies indicate a possible requirement of 21 and also 5, 7, 10, 13, 18 by Plasmodium. /26/ Methyl purines e. g. theobromine, theophylline, caffeine s some ciliates and Suctoria.

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6. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: MISCELLANEOUS GROWTH FACTORS

As the title suggests, this table lists compounds that favorably affect or are essential for the growth process in some aspect but which have not found ready classification in tables 1, 2, 3, 4, 5, 7, 8, 9. Many of these compounds, in addition to the specific activity which they have for some organisms, are utilized by others simply for their carbon, nitrogen and/or hydrogen content. In this last respect CO_2, glutamine and asparagine are excellent examples. The characterization "not required" derives either from direct experimental evidence or the absence of data indicating requirement by forms presently studied.

R = Required by all forms studied; ∄ = Not required by any forms studied; r = Required by one or more species or strains; rm = Required by one or more mutants; "u=" = Replaces effectively or utilized interchangeably with one or more other substances, but one of the interchangeable substances must be present; s = Stimulates growth or other processes for one or more species or strains; i = Inhibits growth or other processes for one or more species or strains.

	Groups of Organisms / Nutrient Compound	Plants						Animals			
									Invertebrates		
		Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(R)	(I)	(J)	(K)
1	Adenylthiomethylpentose[4]	∄	∄	∄	∄	∄	∄	∄	∄		∄,s
2	Anthranilic acid[5]	∄	r,rm[6]	∄	u=[6]	∄	∄	∄	∄		∄,s
3	Antibiotics[7]	∄,s	∄,s	∄	r[8]	∄	∄	∄,s	∄		∄,s
4	Asparagine	∄	∄	∄,s,i	r[9]	∄	∄	∄	∄		∄
5	"Bifidus" factor[10]	∄	∄	∄	r	∄	∄	∄	∄		∄
6	Carbon dioxide	R	r[11],s,i		r[11],s	R	R[12],s	r[13]	∄		∄
7	Carnitine[14]	∄	∄	∄	∄	∄	∄	∄	r[15]		∄
8	Coprogen[16]	∄	r	∄	∄	∄	∄	∄	∄		∄
9	N-D-Glucosylglycine ester	∄	∄	∄	r	∄	∄	∄	∄		∄
10	Glutamine	∄	∄,s,i	s,i	r[9],s	∄	∄	∄	∄		∄
11	Glutathione	∄	∄	∄	r[17]	∄	∄	∄	s[18]		∄
12	Guanidine	∄	∄		∄	∄	∄	r?[19]	∄		∄

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including colorless phytoflagellates. /4/ "Vitamin L_2," a purine nucleoside. /5/ "Vitamin L_1," precursor of nicotinic acid. /6/ Substitutes for tryptophan and/or indole. /7/ Aureomycin, penicillin, streptomycin, bacitracin neomycin and other substances e.g. arsenicals and sulfonamides which may s in small amounts. /8/ R by "dependent" mutants. /9/ R as growth factor and not replaceable by aspartic or glutamic acids. /10/ α and β-Methyl-N-acetyl-d-glucosaminide? /11/ R by some in higher than atmospheric concentrations. /12/ R although another carbon source is available, particularly in darkness. Functions in metabolism of C_3 and C_4 compounds; in Wood-Werkman reaction. /13/ R by some colorless phytoflagellates. /14/ α-hydroxy-γ-aminobutyric acid. /15/ R by Tenebrio molitor; interchangeable with γ-amino-β-hydroxybutyric acid. /16/ Fe containing molecule of unknown structure, not a heme compound. /17/ R by Neisseria gonorrhoeae. /18/ Favors larval growth of Drosophila and Aedes aegypti. /19/ Possibly R by Plasmodium in vitro; ∄ by Tetrahymena.

6. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: MISCELLANEOUS GROWTH FACTORS (Concluded)

As the title suggests, this table lists compounds that favorably affect or are essential for the growth process in some aspect but which have not found ready classification in tables 1, 2, 3, 4, 5, 7, 8, 9. Many of these compounds,in addition to the specific activity which they have for some organisms, are utilized by others simply for their carbon, nitrogen and/or hydrogen content. In this last respect CO_2, glutamine and asparagine are excellent examples. The characterization "not required" derives either from direct experimental evidence or the absence of data indicating requirement by forms presently studied.

R = Required by all forms studied; Ø = Not required by any forms studied; r = Required by one or more species or strains; rm = Required by one or more mutants; "u=" = Replaces effectively or utilized interchangeably with one or more other substances, but one of the interchangeable substances must be present; s = Stimulates growth or other processes for one or more species or strains; i = Inhibits growth or other processes for one or more species or strains.

Nutrient Compound \ Groups of Organisms	Plants							Animals		
								Invertebrates		
	Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
13 Indole-3-acetic acid[20]	Ø,s	r?,s	Ø	Ø,s	Ø,s	Ø,s[21]	Ø[21],i	Ø			Ø,s?
14 Hematin[22]	Ø	r	Ø	r	Ø	Ø	r	r			Ø
15 Krebs cycle intermediates[23]	Ø	r	Ø	r	Ø	r[24],s	Ø,s[24]	Ø			Ø
16 Mucin	Ø	Ø	Ø	r[25]	Ø	Ø	Ø	Ø			
17 Mycobactin[26]	Ø	Ø	Ø	r[27]	Ø	Ø	Ø	Ø			Ø,s
18 Parahydroxybenzoic acid	Ø	rm	Ø	rm	Ø	Ø	Ø	Ø			Ø
19 Putrescine	Ø	rm	Ø	r,u=[28]	Ø	Ø	Ø	Ø			Ø
20 Quinic acid[29]	Ø	rm	Ø	rm	Ø	Ø	Ø	u=[30]			Ø
21 Shikimic acid[29]	Ø	rm	Ø	rm	Ø	Ø	Ø	u=[30]			Ø
22 Spermidine[31]	Ø	Ø	Ø	r,u=[28]	Ø	Ø	Ø	Ø			Ø
23 Strepogenin[32]	Ø	Ø,s?	Ø	r,rm,s	Ø	Ø	Ø	Ø			Ø,s?
24 Thioctic acid[33]	Ø	Ø	Ø	r	Ø	Ø	r[34]	Ø			Ø
25 Unidentified factors[35]		r		r			r	r			r

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including colorless phytoflagellates. /20/ And related auxins (plant hormones) e.g. β-indoleacetic, naphthalene acetic, phenylacetic acids etc. /21/ s Euglena gracilis (green phytoflagellate), ineffective for Astasia (colorless counterpart of Euglena). /22/ Also hemin, protohemin, protoporphyrin and several porphyrins. /23/ Acetate, citrate, fumarate, α-ketoglutarate, oxalacetate, succinate, cis-aconitate, isocitrate, malate, oxalo-succinate. /24/ Several utilized for growth by the "acetate" flagellates; acetate utilized by most; wide variation among species with respect to utilization or availability of individual Krebs intermediates and related compounds such as pyruvate. /25/ Corynebacterium diphtheriae. /26/ C_{47} H_{75} O N_5. /27/ Mycobacterium johnei. /28/ Interchangeable with spermidine for some. /29/ Probable precursors of aromatic amino-acids. /30/ Spares or replaces phenylalanine, tyrosine for Blatella germanica./31/ Also agmatine, spermine. /32/ Also d-alanyl-histidine, amino-n-butyryl-L-histidine, carnosine, various tyrosine peptides. /33/ Protogen or α-lipoic acid. Exists in tissues as lipothiamide (q.v.) which catalyzes the oxidation of pyruvate and α-ketoglutarate. /34/ R by Tetrahymena geleii (8 strains), T. vorax (2 strains); spared but not replaced by acetate; R? by Peranema trichophorum. /35/ For example tissue extracts, unknown substances or complexes in living tissue or protoplasm.

7. NUTRIENTS: GENERAL NITROGEN SOURCES

Nitrogen is a universal requirement of living organisms. Utilizable as molecular N_2 by some organisms, it is required by most in the form of its compounds. This tabulation lists the important classes of nitrogen compounds utilizable from an environmental or dietary source for general nitrogen metabolism. Certain nitrogen compounds which serve as adequate general nitrogen sources for some organisms are required as specific growth factors or essential nutrients by others e.g. the purine, pyridine and pyrimidine compounds.

R = Required by all forms studied; R̸ = Not required by any forms studied; r = Required by one or more species or strains; rm = Required by one or more mutants; U = Utilized by all forms studied; U̸ = Not utilized by any forms studied; u = Utilized by one or more species or strains; u̸ = Not utilized by one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; * = Serves as adequate or partial N-source for one or more species or strains; ** = simplest adequate N-source for one or more species or strains.

Nitrogen Source \ Groups of Organisms	Plants						Animals			
								Invertebrates		
	Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phytoflagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1 Nitrogen Source	R	R	R	R	R	R	R	R	R	R
Inorganic Nitrogen Sources										
2 Nitrogen, molecular, N_2	u[4]	R̸,u?[5]	R̸	u**[6]	R̸,u**[7]	U̸	U̸	U̸		U̸
3 Ammonia, -ium, NH_3, $-NH_4^+$	R̸,U**	rm,u**[8]	R̸,u**	R̸,u*[9]	R̸,U**[10]	R̸,U**	r,u**	R̸,u?		R̸,u[11]
4 Hyponitrite, $-HN_2O_2^-$ or $-N_2O_2^=$	R̸,u̸[12]	R̸,u̸[13]		R̸,u[14]	R̸	R̸	R̸	R̸		R̸
5 Nitrite, $-NO_2^-$	R̸,u*[15]	rm,u**[16]	R̸,u*	R̸,u*	R̸,u*[17]	R̸	R̸	R̸		R̸
6 Nitrate, $-NO_3^-$	R̸,U*	rm,u**[18]	R̸,u*[19]	R̸,u*[20]	R̸,U*[21]	R̸,u*[22]	R̸,u	R̸		R̸
7 Nitrohydroxamate, $-HN_2O_3^-$	R̸,u*[23]	R̸,u*[24]	R̸	R̸	R̸	R̸	R̸	R̸		R̸
8 Cyanide, $-CN^-$	U̸	R̸,u*[25]	R̸	R̸	R̸	R̸	U̸[26]	U̸[26]		U̸[26]
9 Thiocyanate, $-CNS^-$	U̸	R̸,u?	R̸,u	R̸,u*	R̸	R̸	U̸	U̸		U̸
10 Cyanamide, $-NHCN^-$	U̸	u*[27]	R̸	R̸,u*[27]	R̸	R̸	U̸	U̸		U̸

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including the colorless phytoflagellates. /4/ U by virtue of symbiotic bacteria as in root nodules of legumes. /5/ Evidence for N_2 fixation conflicting. /6/ U by N_2 fixing bacteria. /7/ N_2 "fixation" by blue-green algae, Nostocaceae. U̸ if H_2 or CO present. /8/ U by Phycomyces blakesleeanus, Mucorales. Probably U by all fungi. /9/ Many bacteria R specific amino acids from the environment but as a class, U NH_4^+ for synthesis of other amino acids. /10/ U in preference to NO_3^- by Chlorella. /11/ Dietary NH_4^+ U by ruminants; possibly others; NH_4^+ originating as metabolic intermediate U in amino acid synthesis. /12/ U̸ by tobacco plant. /13/ U̸ by Aspergillus niger. /14/ U by Clostridium pasteurianum, but not for growth; U̸ for denitrification by Pseudomonas stutzeri. /15/ Toxic to many plants, poorly U by tobacco plant. /16/ U as sole N-source by many fungi. /17/ U poorly by Chlorella pyrenoidosa. /18/ Acts as sole H acceptor in anaerobic metabolism of Aspergillus niger. R by some when mannitol is carbon source. Some R NO_3^-, cannot substitute NH_4^+. /19/U poorly by most yeasts. /20/ U̸ by purple photosynthetic bacteria. /21/ U in light, U̸ in dark by some. /22/ U in light, U̸ in dark by some; U̸ either in light or dark by some. /23/ Good N-source for tobacco plant. /24/ Good N-source for Aspergillus niger. /25/ U by Aspergillus niger when N-starved. /26/ Toxic. /27/ Cyanamide and derivatives U by many.

7. NUTRIENTS: GENERAL NITROGEN SOURCES (Concluded)

Nitrogen is a universal requirement of living organisms. Utilizable as molecular N_2 by some organisms, it is required by most in the form of its compounds. This tabulation lists the important classes of nitrogen compounds utilizable from an environmental or dietary source for general nitrogen metabolism. Certain nitrogen compounds which serve as adequate general nitrogen sources for some organisms are required as specific growth factors or essential nutrients by others e.g. the purine, pyridine and pyrimidine compounds.

R = Required by all forms studied; ℵ = Not required by any forms studied; r = Required by one or more species or strains; rm = Required by one or more mutants; U = Utilized by all forms studied; ℶ = Not utilized by any forms studied; u = Utilized by one or more species or strains; ℸ = Not utilized by one or more species or strains; s = Stimulates growth or other processes for one or more species or strains; * = Serves as adequate or partial N-source; ** = Simplest adequate N-source for one or more species or strains.

Nitrogen Source \ Groups of Organisms	Plants						Animals			
								Invertebrates		
	Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phytoflagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Organic Nitrogen Sources									
11 Oximino compounds[28], $RONH_2$	ℵ,U[29]	ℵ,u*	ℵ,u?	ℵ,u*[30]	ℶ[31]	ℵ	ℵ	ℵ		ℵ
12 Amines[32], RNH_2	ℵ	ℵ,u*	ℵ,u*	ℵ,u*	ℵ,u*[33]	ℵ	ℵ	ℵ		ℵ
13 Acid imides[34], $(RCO)_2NH$	ℵ	ℵ	ℵ	ℵ,u*	ℵ	ℵ	ℵ	ℵ		ℵ
14 Acid amides[35], $RCONH_2$	ℵ,u*[36]	ℵ,u*[37]	r,u*	ℵ,u*	ℵ,u*	ℵ	ℵ	ℵ		ℵ
15 Urea, $(NH_2)_2CO$	ℵ,U*	ℵ,u*	ℵ,u*	ℵ,u*	ℵ,u*	ℵ,u*	ℵ,u*[38]	ℵ		ℵ,u[39]
16 Amino acids[40], $RCH(NH_2)COOH$	ℵ,u*	r,rm,U*	r,U*	r[9],U*,s	ℵ,u*[41]	r,u*	r,u*	R,U**	R.U**	R,U**[11]
17 Peptides, polypeptides[42]	ℵ,u*	ℵ,u*	ℵ,u*	r,u*,s	ℵ,u*	ℵ,u*	r,u*	ℵ		ℵ,U*
18 Proteins	ℵ	ℵ,u*	ℵ	ℵ,u*	ℵ	ℵ	r,u*	ℵ,U*	U*	ℵ[43],U*,s
19 Imidazole compounds[44]	ℵ	ℵ,u*	ℵ,u*	ℵ,u*	ℵ	ℵ	ℵ	ℵ		ℵ
20 Pyridine compounds[45]	ℵ	ℵ	r	r,u*	ℵ	ℵ	r	r		r
21 Pyrimidine compounds[46]	ℵ	ℵ,u*,s	ℵ,u*	ℵ,u*,s	r	r	r,u*	r		R
22 Purine compounds[47]	ℵ,u	rm,u*,s	ℵ,u	ℵ,u*,s	ℵ	ℵ	r,u*	ℵ		ℵ
23 Indole compounds[48]	ℵ,s	rm,u*	ℵ	ℵ,u*.s	ℵ,s	ℵ,s	ℵ	ℵ		ℵ

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including the colorless phytoflagellates. /9/ Many bacteria R specific amino acids from the environment but as a class, U NH_4^+ for synthesis of other amino acids. /11/ Dietary NH_4^+ originating as metabolic intermediate U in amino acids synthesis. /28/ Including hydroxylamine. /29/ Hydroxylamine poor N-source. /30/ Hydroxylamine U by Clostridium welchii, U in non-toxic concentration by Nitrosomonas. /31/ Hydroxylamine toxic. /32/ Alkylamines, as methylamine, CH_3NH_2 and arylamines, as benzylamine, $C_6H_5CR_2NH_2$. /33/ Glucosamine U. /34/ e. g., Succinimide. /35/ e. g., Formamide, $HCONH_2$, acetamide; also asparagine. /36/ Acetamide U by some. /37/ Formamide and others U by Aspergillus. Both amino and amide N of asparagine U by Aspergillus. /38/ U by Astasia longa (colorless phytoflagellate) /39/ U by ruminants via rumen microflora. /40/ See Table 2. /41/ L-arginine, glutamine, cysteine, L-asparagine support more rapid growth of Chlorella than does NH_4^+. /42/ Including peptones, synthetic di- and tri- peptides, "strepogenin", glutathione. /43/ Proteins as such are listed as ℵ for vertebrates because only certain amino acids are actually R. /44/ e. g., Allantoin, creatinine, guanidine. /45/ e. g., Niacin, pyridine. /46/ e. g., Pyrimidine, alloxan, pyrimidine moiety of thiamine, nucleic acids, nucleotides. /47/ e. g., Uric acid, caffeine, theobromine, nucleic acids, nucleotides. /48/ e. g., Indole, indoleacetate.

8. NUTRIENTS: GENERAL CARBON SOURCES

R = Required by all forms studied; ∄ = Not required by any forms studied; U = Utilized by all forms studied; ∅ = Not utilized by any forms studied. r = Required by one or more species or strains; u = Utilized by one or more species or strains; * = May serve as sole or partial C-source for one or more species or strains; ** = Simplest C-source for at least one of a group.

Carbon Sources \ Groups of Organisms	Plants						Animals			
	Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phyto-flagellates[2]	Protozoa[3]	Invertebrates: Insects	Invertebrates: Other	Vertebrates
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Inorganic									
1 Carbon, amorphous, C	∅	u?	∅	u**?	∅	∅	∅	∅		∅
2 Carbon monoxide, CO	∅	∅	∅	u[4]	∅?	∅	∅	∅		∅
3 Carbon dioxide, CO_2	R,U**	r,U		r,u**	R,U**	r,U**	r,u*[5]	U?		U
4 Bicarbonates, $-HCO_3^-$	R,U**	U		r,u**	U**?	r,U**	r,u*[5]	U?		U
5 Cyanogens, $-CN^-$	?	u		u						
	Organic									
6 Alkanes, alkenes	∅	u	∅	u[6]	∅	∅	∅	∅		∅
7 Alcohols	u	u*	u	u	∄,u	∄,u	u	u		U
8 Aldehydes	∄	u	u	u	∄	∄	∄	∄		∄,u
9 Ketones	∄	∅		u	∄	∄	u	∄		∄,u
10 Acids	∄	u*	u	u	∄,u	∄,u	u	r,U		r,U
11 Carbohydrates	U[7]	U*	U*	U*	∄,u	∄,u	r,u[8]	r,U		U
12 Glycosides	∄	u	u	u	u	∄,u	∄	∄		∄,u
13 Fats	∄,∅	u	u	u	∄,∅	∄,∅	u	r,U[9]		U
14 Waxes	∄,∅	u*		u	∄,∅	∄,∅	∄,∅	u		u
15 Amino acids, peptides; proteins	∄,u	u*	u	u	∄,u	∄,u	u	u		R,U

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Colorless phytoflagellates. /4/ U by Carboxydamonas oligocarbophila and Methanosarcina barkerii. /5/ U by Tetrahymena geleii, condensation with pyruvate, oxalacetate, succinate; R by Chilomonas paramecium, Astasia longa (but not in acetate medium), Polytomella caeca on media containing casein hydrolysate, also on acetate medium. /6/ U by Methanosarcina methanica; also U ethane, propane, butane, hexane, propylene, butylene, paraffin oils; U by Bacterium aliphaticum-liquefaciens: H_2, pentane, hexane, heptane, octane, decane, cetylbenzol; U by others: gasoline, kerosene, mineral oils, paraffin wax, etc. /7/ U by isolated tissue, e.g. roots; callus and tumor tissues; by green plants in aseptic culture. /8/ Carbohydrate C-source ∄ by Tetrahymena geleii except when utilizing NH_4^+ in medium low in amino acids. /9/ Insects ∄ dietary fats with exception of specific lipids as "growth substances", "vitamins".

9. NUTRIENTS: GENERAL SULFUR SOURCES

Sulfur occurs in the amino acids cysteine, cystine and methionine. The last of these is required by all animal forms studied and may be an essential in the protein structure of all living organisms. Sulfur occurs also in chondroitin sulfuric acid, a component of vertebrate connective tissue, and in sulfo-lipids found in white matter of brain and in other tissues. Emphasis is on utilization (U, u) of a compound as a sulfur source.

R = Required by all forms studied; ✗ = Not required by any forms studied; r = Required by one or more species or strains; rm = Required by one or more mutants; U = Utilized by all forms studied; ✗ = Not utilized by any forms studied; u = Utilized by one or more species or strains.

	Sulfur and Sulfur Compounds \ Groups of Organisms	Plants						Animals		
								Invertebrates		
		Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phytoflagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Sulfur source	R	R	R	R	R	R	R	R	R	R
	Inorganic Sulfur Sources										
2	Sulfur[4] (elemental), S	✗,✗	u[5]	u	r[6]	✗,✗	✗	✗	✗		✗,u[7]
3	Sulfhydryl, $-SH^-$	✗	u			✗	✗	✗	✗		✗
4	Sulfide, $-S^=$	✗	u[8]		u[9]	✗,u[10]	✗	✗	✗		✗,✗
5	Bisulfite, $-HSO_3^-$	✗	u[11]			✗	✗	✗	✗		✗,✗
6	Sulfite, $-SO_3^=$	✗,u	u[11]		u[12]	✗	✗	✗	✗		✗,✗
7	Sulfate, $-SO_4^=$	U	u[11]	u	r	U	U	r	✗		✗,u[13]
8	Thiosulfate, $-S_2O_3^=$	✗,u	rm,u		u[14]	✗	✗	✗	✗		✗,✗
9	$-S_2O_8^=$[15]	✗	u?			✗	✗	✗	✗		✗
10	Tetrathionate, $-S_4O_6^=$	✗			u	✗	✗	✗	✗		✗
11	Sulfoxylate, $-SOOH^-$	✗	u[16]		u	✗	✗	✗	✗		✗
12	-SO as Sulfur hydrate, H_2SO	✗			u	✗	✗	✗	✗		✗
13	Thiocyanate, $-SCN^-$	✗	u		u[17]	✗	✗	✗	✗		✗
14	Persulfate	✗	u[11]			✗	✗	✗	✗		✗

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including the colorless phytoflagellates. /4/ i. e., the substance not in combination with other elements. /5/ U by Fusarium lini. /6/ U by Thiobacillus thio-oxidans, Sporovibrio desulfuricans, S. aestuarii, Thiorhodaceae. /7/ Bacteria, in ruminants, build the element into amino acids (methionine; cystine). /8/ Some aquatic fungi, e. g., members of the Blastocladiales and Saprolegniales, ✗ oxidized sulfur; these require a reduced sulfur source, e. g., H_2S, cysteine, cystine, methionine, thioacetate, thiocarbonate, thioglycolate, thiourea. /9/ U, e. g., by Beggiatoa, Thiothrix, Thioploca, Thiobacilli. /10/ Synechococcus, grown in an atmosphere of N_2, U Na_2S (with reduction of CO_2); Oscillaria and Pinnularia also reduce CO_2 with H_2S, depositing S in their cells. Scenedesmus also U sulfide. H_2S toxic to Chlorella. /11/ U by Brevilegnea gracilis; ✗ by many other Saprolegniaceae. /12/ U by Sporovibrio desulfuricans, S. aestuarii. /13/ U for formation of chondroitin sulfate and heparin; U by laying hen by conversion to cystine. /14/ U by Thiobacillus novellus, Pseudomonas aeruginosa, Ps. fluorescens, Achromobacter stutzeri, others. /15/ Decomposes on contact with H_2O. /16/ Inorganic sulfur less oxidized than sulfinate not efficiently U by Aspergillus niger. /17/ NH_4SCN can be U by Bacillus thiocyan-oxidans as sole source of C, N and S.

9. NUTRIENTS: GENERAL SULFUR SOURCES (Concluded)

Sulfur occurs in the amino acids cysteine, cystine and methionine. The last of these is required by all animal forms studied and may be an essential in the protein structure of all living organisms. Sulfur occurs also in chondroitin sulfuric acid, a component of vertebrate connective tissue, and in sulfo-lipids found in white matter of brain and in other tissues. Emphasis is on utilization (U,u) of a compound as a sulfur source.

R = Required by all forms studied; R̸ = Not required by any forms studied; r = Required by one or more species or strains; rm = Required by one or more mutants; U = Utilized by all forms studied; U̸ = Not utilized by any forms studied; u = Utilized by one or more species or strains.

Sulfur and Sulfur Compounds \ Groups of Organisms	Plants						Animals			
								Invertebrates		
	Higher Green Plants[1]	Fungi	Yeasts	Bacteria	Algae	Green Phytoflagellates[2]	Protozoa[3]	Insects	Other	Vertebrates
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Sulfur Containing Amino Acids, Sulfoproteins[18]									
15 Cystathionine	R̸	u		u	R̸	R̸	R̸,u	u		u
16 Cysteine	R̸,u	u[8]	u	r	R̸,u[19]	R̸,u	u	u[20]		U
17 Cystine	R̸,u	u[8]	u	r	R̸	R̸,u	u	u		U
18 Homocysteine	R̸	U		u	R̸	R̸	R̸,u	u		u
19 Homocystine	R̸	U		u	R̸	R̸	R̸,u	u		u
20 Methionine	R̸,u	U	u	r	R̸,U̸	r	r	r[21]		R
21 Peptones	R̸,u	U	u	u	R̸,u	u	r	u		R̸,U
	Sulfur Containing Vitamins and Growth Factors[18]									
22 Biotin[22]	R̸	u	u	u	R̸	r	r?	r		R?U
23 Coenzyme A	R̸	R̸	R̸	R̸	R̸	R̸	R̸	R̸		R̸,U
24 Glutathione ("G-SH")[23]	R̸	u	u	r	R̸	u	R̸,u	r		R̸,U
25 Thiamine[24]	R̸	U̸	r	r	u	r	r	r		R
26 Thiazole[24]	R̸	u?[25]	r[26]	r[26]	r	r[26]	r[26],u	R̸		R̸
27 Thioctic acid[27]	R̸	R̸	R̸	r[28]	R̸	R̸	r[29]	R̸		R̸
	Other Sulfur Sources									
28 Miscellaneous compounds[30]										

/1/ Spermatophytes (the intact plant). /2/ Green phytoflagellates, chrysomonads, dinoflagellates. /3/ Including the colorless phytoflagellates. /8/ Some aquatic fungi, e. g., members of the Blastocladiales and Saprolegniales, U̸ oxidized sulfur; these require a reduced sulfur source, e. g., H_2S, cysteine, cystine, methionine, thioacetate, thiocarbonate, thioglycolate, thiourea. /18/ R, r, U, u, may mean as a sulfur source, or the compound may be R for its molecular structure, not synthesized by the organism. /19/ U as N-source (and sulfur source?) by Chlorella pyrenoidosa. /20/ Also U cysteic acid, isethionic acid. /21/ Also U methionine sulfoxide, taurine. /22/ Biotin R by numerous fungi, yeasts, bacteria and by most of the vertebrates and invertebrates studied. The replacement of S in the biotin molecule does not affect the activity for some bacteria. /23/ Complex of cysteine, glycine and glutamic acid. /24/ Thiamine, containing pyrimidine and thiazole (the latter an imidazole ring with one C replaced by sulfur) is R by numerous organisms, probably also a sulfur source? /25/ U̸ as sulfur source by Aspergillus niger (cannot rupture the thiazole ring?). /26/ Satisfies thiamine requirement for some (cf. Fn 24); probably a sulfur source? /27/ = Protogen, or α-lipoic acid./28/ R by Streptococcus fecalis for oxidation of pyruvate. /29/ R by Tetrahymena geleii (8 strains), T. vorax (2 strains). /30/ Many compounds containing S have been tested on a wide variety of organisms. Typical of these compounds are the alkylsulfides, sulfinates and sulfonates; the sulfoxides, sulfamates and sulfonic acid amides ; ethereal sulfates; taurine; the thiols and thio-compounds: -acetamide, -acetate, -carbonate, -glycolate, -oxalate, -urea. Many of these are U by some fungi and bacteria, and certain of the thio-salts are R by some fungi. Most of these S-containing compounds are R̸ by plants, algae, green phytoflagellates, protozoa, invertebrates and vertebrates.

10. UTILIZATION OF CHEMICAL ELEMENTS: INSECTS

All species of insects utilize nitrogen, carbon, oxygen and hydrogen which in various molecular combinations constitute the structure of their bodies and their food. In addition phosphorus, sulfur, iron, copper, magnesium, manganese, potassium, calcium and chlorine are probably universal requirements of insects. A number of different minerals, some only as traces, also are consumed and are found present in the constitution of the insect. One can suppose that the mineral composition of the insect may influence considerably the chemical reactions taking place in the tissues, but it is difficult to ascertain whether or not some of these trace elements are utilized specifically. The present data are taken mainly from studies in which the insect is noticeably affected by the presence or absence of a mineral element in its rearing medium or food.

Utilized (U); Not Utilized (∅)

Element \ Organism	Orthoptera		Coleoptera	Lepidoptera					Diptera									Homoptera	Siphonaptera
	Cockroach, American, adult (Periplaneta americana (L.))	Grasshopper, egg (Melanoplus differentialis)	Beetle, confused flour, larva (Tribolium confusum Duv.)	Leafworm, cotton, larva (Alabama argillacea (Hbn.))	Moth, cecropia; larva (Platysamia cecropia)	Moth, eyed-hawk, larva (Smerinthus ocellatus (L.))	Silkworm, larva (Bombyx mori (L.))	Silkworm, adult[1] (Bombyx mori (L.))	Fly, flesh, larva (Sarcophaga falculata)	Fly, fruit, larva (Drosophila melanogaster)	Fly, greenbottle; larva (Lucilia sericata (Meig.))	Fly, house, adult (Musca domestica (L.))	Mosquito, larva (Aedes concolor Tayl.)	Mosquito, larva (Aedes aegypti (L.))	Mosquito, larva (Culex pipiens)	Mosquito, larva (Theobaldia incidens (Thoms.))	Parasite of spruce bud worm, larva (Pseudosarcophaga affinis)	Aphid, rose[2] (Macrosiphum rosae (L.))	Flea, rat, larva (Nosopsyllus fasciatus (Bosc.))
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
1 Antimony																		U	
2 Calcium	U									U?[3]		U	U[4]	U		U	∅	∅	
3 Carbon[5]	U	U	U	U	U	U	U		U	U	U	U	U	U	U	U	U	U	U
4 Chlorine										U				∅	U		∅[6]		
5 Cobalt								∅[7]		∅[8]									
6 Copper		U		U				U	U										
7 Hydrogen[5]	U	U	U	U	U	U	U		U	U	U	U	U	U	U	U	U	U	U
8 Iron	U				U			U		U		U				∅	∅		U
9 Lead						U[9]												U	
10 Magnesium										U		U		∅		U	∅	U	
11 Manganese										U		U[10]							
12 Mercury								∅[7]							∅[7]			U	
13 Nickel																		U	
14 Nitrogen[5]	U	U	U	U	U	U	U		U	U	U	U	U	U	U	U	U	U	U
15 Oxygen[5]	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
16 Phosphorus[5]	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
17 Potassium	U							U[11]		U				∅			U	∅	
18 Sodium							∅	U		U?[3]			U[4]	∅		U	∅		
19 Sulfur[5]	U	U	U	U	U	U	U		U	U	U	U	U	U	U	U	U[12]	U	U
20 Tin																		U	
21 Zinc				U														U	

/1/ Utilization judged by effect of the element on fecundity. /2/ Utilization judged by influence of the element on occurrence of alate forms. /3/ Reported by some (q.v.) as not utilized by Drosophila except possibly in trace amounts. /4/ In balanced solution only. /5/ Universal constituent of protoplasm. /6/ Absent from chemically defined nutrient medium except as hydrochlorides of amino-acids or vitamins. /7/ Toxic for this organism. /8/ Based on non-utilization of cobalamin. /9/ As $Pb(NO_3)_2$. /10/ Replaceable by magnesium. /11/ Utilized as KOH but not as KCl. /12/ Absent from the chemically defined nutrient medium except as occurring in sulfur containing amino acids.

11. UTILIZATION OF PROTEINS: INSECTS

Utilized (U)

	Protein \ Organism	Orthoptera	Coleoptera								Lepidoptera				Diptera	
		Cockroach, German, nymph (Blattella germanica (L.))	Beetle, carpet; larva (Attagenus (sp.))	Beetle, cigarette; larva (Lasioderma serricorne (Fab.))	Beetle, confused flour; larva (Tribolium confusum Duv.)	Beetle, drugstore; larva (Stegobium paniceum (L.))	Beetle, hide; larva (Dermestes maculatus Deg.)	Beetle, saw-toothed grain; larva (Oryzaephilus surinamensis (L.))	Beetle, spider; larva (Ptinus tectus Boield)	Mealworm, yellow; larva (Tenebrio molitor L.)	Corn borer, European; larva (Pyrausta nubilialis (Hbn.))	Moth, Mediterranean flour; larva (Ephestia kuehniella Zell.)	Moth, tobacco; larva (Ephestia elutella (Hbn.))	Moth, webbing clothes; larva (Tineola bisselliella (Hum.))	Fly, vinegar, fruit, larva (Drosophila melanogaster Meig.)	Mosquito, yellow-fever; larva (Aedes aegypti (L.))
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)
1	Proteins, total[1]	15-30%	6-12%	45%	15-45%	45%		45%	45%	15-45%	20-30%	45%	20%	20-80%	2-3%	
2	Brain protein[2]				U[3]		U[3]			U[3]						
3	Casein	U[3]	U[3]	U[3]	U[3]	U[3]	U[3]	U[3]	U[3]	U[3]	U	U[3]	U[3]	U[3]	U[3]	U[3]
4	Cotton seed protein				U[3]		U[4,5]			U[4]						
5	Edestin[6]				U[4]					U[4]						
6	Fibrin[7]	U[3]			U[3]		U[3]			U[4]	U[8]					
7	Gelatin	U[4]			U[8]					U[8]					U[8]	
8	Gliadin[9]				U[4]					U[8]						
9	Gluten, wheat	U[4]			U[3]					U[3]	U[8]					
10	Glycinin[10]				U[3]		U[4]			U[5]						
11	Hemoglobin	U[4]														
12	Lactalbumin[11]	U[4]		U[3]	U[3]		U[3]			U[3]	U[8]					
13	Liver Protein				U[3]		U[3]			U[3]						
14	Peanut protein				U[3]		U[3]			U[3]						
15	Soybean protein				U[3]		U[3,8]			U[4]						
16	Zein[12]	U[8]			U[4]		U[8]			U[8]	U[8]					

/1/ Percentage of protein in diet required to maintain growth and development. /2/ Wilson B protein. /3/ maintains good growth and development. /4/ Maintains only poor growth and development. /5/ Only when heated. /6/ A complete globulin from hemp seed. /7/ From blood. /8/ Maintains little or no growth and development. /9/ A protein separable from wheat gluten. /10/ A globulin constituting 90-95% of protein content of soy bean. /11/ From milk. /12/ An alcohol soluble protein from maize (corn).

12. AMINO ACID REQUIREMENTS: MAN AND OTHER VERTEBRATES

Values are considered adequate for satisfactory growth, or maintenance or recovery from protein depletion, as specified in the column headings. Twice the values should give an acceptable margin of safety where such is desired (cf also Fn 4). Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species.

Essential[1] (R); Utilized[2] (U)

	Specifications / Amino Acid per kg body weight per day	Man[3,4]	Rat[5]			Mouse	Chicken[6]	Turkey[7]	Dog[8]		Swine[9]
		Adult	Young[10]	Adult	Adult	Young	Young[11]	Young	Young[12]	Adult[13]	Young
		♂70 kg	♂♀0.05 kg	0.15 kg	0.15 kg	0.025 kg	♂♀0.25 kg	♂♀0.52 kg	♂♀1.5 kg	♂♀7 kg	♂♀45 kg
		Nitrogen Balance	Growth	Maintenance	Repletion[14]	Growth	Growth	Growth	Growth	Nitrogen Balance[15]	Growth
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	L-Alanine	U	U	U	U						
2	L-Arginine, mg	U	R900[16]	U	U	?	R1870	R1600	270[17]	70[17]	R135
3	L-Aspartic acid	U		U	U						
4	L-Citrulline	U									
5	L-Cystine, mg	U	U[18]	U	U		R?540[19]	U320[19]			
6	L-Glutamic acid	U	U[20]	U	U						
7	Glycine, mg	U	U	U	U		R1560	R1000			
8	L-Histidine, mg	U	R1600	R35	R120	R	R230		60[17]	25[17]	R260
9	L-Hydroxyproline	U	U		U						
10	L-Isoleucine, mg	R10	R1800	R180	R345	R	R930	R860	330[17]	80[17]	R320
11	L-Leucine, mg	R15.5	R2750	R110	R415	R	R2180		370[17]	110[17]	R520
12	L-Lysine, mg	R11.5	R2750	R60	R330	R	R1400	R1400	220[17]	60[17]	R650
13	L-Methionine, mg	R15.5	R1800	R90	R220	R	R700	R520	210[17]	70[17]	R390
14	L-Phenylalanine, mg	R15.5	R2750	R50	R255	R	R1400		190[17]	65[17]	R580
15	L-Proline	U	U[20]								
16	L-Serine	U	U								
17	L-Threonine, mg	R7	R1600	R85	R245	R	R930		140[17]	55[17]	R260
18	L-Tryptophan, mg	R3.5	R900	R30	R80	R	R310	R270	60[17]	15[17]	R130
19	L-Tyrosine, mg	U	U[21]	U	U		R?1090				
20	L-Valine, mg	R11.5	R2300	R120	R290	R	R1240		300[17]	85[17]	R260

/1/ An essential amino acid (R) is an indispensable component of the diet because it is not synthesized, from materials ordinarily available, at a speed sufficient for maintenance of nitrogen balance in the adult and/or normal growth in the young. /2/ A non-essential amino acid can be synthesized in adequate amounts in the body from other nitrogen sources if not supplied in the diet. Non-essential amino acids can be utilized by man and probably by most other vertebrates. /3/ To obtain recommended intake per person (adult) per day, multiply values by 70 regardless of actual weight unless it represents an extreme departure from 70 kg. Rose, W. C., finds that requirement does not vary with weight in adult male. /4/ The values in this column represent the minimum requirements as determined for young, healthy males; twice these values is considered a "safe" allowance for normal, healthy males and females, but they probably should be increased more than twice for growth, rehabilitation from disease, and during pregnancy and lactation. /5/ White rat. /6/ New Rampshire. Values in this column are based on a daily food intake of 39 grams per chick. /7/ Broad Breasted Bronze. Values in this column are based on a daily food intake of 56 grams per turkey. /8/ Cocker spaniel. /9/ Values in this column are based on a synthetic diet with amino acids and diammonium citrate as nitrogen sources. /10/ Values in this column calculated on basis of 10 grams daily food intake per rat, and with cystine and tyrosine lacking in diet. /11/ Amino acid requirement is increased when protein intake is raised. /12/ Amino acids supplied from egg proteins. /13/ Amino acids supplied by egg albumin. /14/ Values in this column represent allowances for rapid weight recovery and protein repletion in adult protein-depleted rats. /15/ Values in this column represent the minimum nitrogen intake that maintained nitrogen balance. /16/ Syntbesized by the rat, but not at sufficient speed for maximum growth. /17/ Data available do not make clear whether all of these amino acids are indispensable or not. /18/ Cystine may replace one sixth of the methionine requirement. /19/ If not supplied in diet, the daily allowance of methionine must be increased correspondingly. /20/ Either glutamic acid or proline may substitute partially for arginine. /21/ If tyrosine is present, the phenylalanine requirement may be decreased.

13. AMINO ACID REQUIREMENTS: INSECTS

Required (R); Not required (Ø)

	Amino Acid[1] \ Organism	Orthoptera	Coleoptera				Diptera			
		Cockroach, German; nymph (Blattella germanica (L.))	Beetle, carpet; larva (Attagenus (sp.))	Beetle, confused flour; larva (Tribolium confusum Duv.)	Beetle, hide; larva (Dermestes maculatus Deg.)	Mealworm, yellow; larva (Tenebrio molitor L))	Fly, green bottle; larva (Phoenicia sericata Meig.)	Fly, fruit, vinegar; larva (Drosophila melanogaster Meig.)	Mosquito, yellow-fever; larva (Aedes aegypti (L.))	Parasite of spruce budworm; larva (Pseudosarcophaga affinis (Fall.))
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
1	Alanine	R	Ø	Ø				Ø	Ø	Ø
2	Arginine	R	R	R[2]				R[3]	R	R
3	Aspartic acid	Ø	Ø	Ø				Ø	Ø	Ø
4	Cystine	R?	Ø	Ø	R		R	Ø	R?	Ø
5	Glutamic acid	Ø	Ø	Ø				Ø	Ø	Ø
6	Glycine	Ø	Ø	Ø				Ø[4]	R	R
7	Histidine	R	R	R[2]				R	R	R
8	Hydroxyproline	Ø	Ø	Ø				Ø	Ø	Ø
9	Isoleucine	R	R	R[2]				R	R	R
10	Leucine	R	R	R[2]				R	R	R
11	Lysine	R	R	R[5]		R		R	R	R
12	Methionine	R?[6]	R	R[5]				R	R	R
13	Norleucine		Ø							
14	Phenylalanine	Ø	R	R[5]				R	R?	R
15	Proline	R[7]	Ø	Ø				Ø	Ø	Ø
16	Serine	R[7]	Ø	Ø				R[8]	Ø	Ø
17	Threonine	Ø	R	R[2]				R	R	R
18	Tryptophan	R?	R	R[2]		R		R	R	R
19	Tyrosine	Ø	Ø	Ø				Ø	Ø?	Ø
20	Valine	R	R	R[2]				R	R?[9]	R

/1/ Diets containing all amino acids produce slightly better growth than mixtures of "required" constituents alone. L-forms are biologically active. /2/ D-form of the amino acid inactive. /3/ Citrulline can partially substitute for arginine. /4/ Required for maximal growth. /5/ D-form of the amino acid active. /6/ In non-sterile cultures. /7/ Required by males only. /8/ D-Serine extremely toxic, and L-Serine slightly toxic. /9/ Requirement or lack of requirement not demonstrated since valine was present in yeast extract, one of the ingredients of the medium.

14. UTILIZATION OF CARBOHYDRATES: INSECTS

Utilized (U); Poorly utilized (u); Not utilized (Ø); Not required (Ø̸)

Organism / Carbohydrate	Isoptera	Orthoptera		Coleoptera										Lepidoptera				
	Termite; adult, (defaunated) (Zootermopsis angusticollis (Hagen)	Cockroach, German; nymph (Blattella germanica (L.))	Grasshopper, two-striped; adult (Melanoplus bivittatus (Say.))	Beetle, carpet; larva (Attagenus (sp.))	Beetle, cigarette; larva (Lasioderma serricorne L.))	Beetle, confused-flour; larva (Tribolium confusum Duv.)	Beetle, drug-store; larva (Stegobium paniceum (L.))	Beetle, powder-post; larva (Lyctus (sp.))	Beetle, saw-toothed grain; larva (Oryzaephilus surinamensis (L.))	Beetle, spider; larva (Ptinus tectus Boield)	Mealworm, yellow; larva (Tenebrio molitor L.)	Weevil, cowpea; larva (Callosobruchus maculatus (F.))	Butterfly, European cabbage; larva (Pieris brassicae (L.))	Butterfly, small tortoise-shell; larva (Aglais urtica (L.))	Cornborer, European; larva (Pyrausta nubilialis (Hbn.))	Moth, buff-tip; larva (Phalera bucephala (L.))	Moth, fig; larva (Ephestia cautella (Walker))
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)
1 Carbohydrates	U	32%[1]	U	Ø̸	U-Ø̸	Ø̸[2]?	50%[1]?	U	U	U-Ø̸[2]	80-85%[1]	U			25%[1]	50-80%[1]	50%[1]
2 Adonitol																	
3 Arabinose						Ø	Ø		Ø		Ø						
4 Arabitol																	
5 Cellobiose						U[3]?					u						
6 Cellulose	Ø	Ø					Ø	Ø̸	Ø						Ø	Ø	
7 Dextrin		U	u			U[3]?			U		U						
8 Dulcitol											Ø						
9 Erythritol																	
10 Fructose	U					Ø[4]	Ø[4]		U		U[4]				U		U[5]
11 Fucose																	
12 Galactose	U		U			Ø	Ø		Ø		Ø						
13 Glucose	U	U	U		U	U	U	U	U	u	U		U	U	U	U	U
14 Glycerol																	
15 Glycogen			u								U						
16 Hemicellulose								Ø̸			u						
17 Inositol		Ø̸															
18 Inulin			u			U[3]?	Ø		Ø		Ø						
19 Lactose	U	U				Ø	Ø		U		u				Ø		
20 Lyxose																	
21 Maltose	U					U	U		U		U				Ø		
22 Mannitol						U	U		U		U						
23 Mannose						Ø	Ø		u		Ø[4]						
24 Melezitose																	
25 Melibiose						U[3]?											
26 β-Methyl fructopyranoside																	
27 α-Methyl galactoside																	
28 β-Methyl galactoside																	
29 α-Methyl glucoside						Ø	Ø?		Ø		Ø						
30 β-Methyl glucoside											Ø						
31 α-Methyl mannoside																	
32 Raffinose						U	U		Ø		U						
33 Rhamnose						U[3]?											
34 Ribose											Ø						
35 Sorbitol						U	Ø[3]		U		U[4]						
36 Sorbose						Ø	Ø		Ø		Ø						
37 Starch	U	U	u		U	U	U	U	U	U	U		Ø	Ø	Ø	Ø	Ø
38 Sucrose	U	U			u?	Ø	Ø	U	Ø		U	U[6]	U	U	U	U	
39 Trehalose																	
40 Xylose			U			Ø	Ø		Ø		u						
41 Other polysaccharides	Ø̸		u														

/1/ Approximate percentage of carbohydrate required in optimum diet. /2/ Grows fairly well in absence of carbohydrates. /3/ Not fully utilized. /4/ Hygroscopic, renders diet unsuitable for growth and survival. /5/ Has retarding effect on growth. /6/ Sugar, presumably sucrose.

14. UTILIZATION OF CARBOHYDRATES: INSECTS (Concluded)

Utilized (U); Poorly utilized (u); Not utilized (Ø); Not required (Ø̸)

Carbohydrate \ Organism	Lepidoptera (concluded)							Diptera								Hymenoptera	
	Moth, Indian-meal; larva (Plodia interpunctella (Hbn.))	Moth, io; larva (Automeris io (F.))	Moth, lackey; larva (Malacosoma neustria (L.))	Moth, Mediterranean-flour; larva (Ephestia kuehniella Zell.)	Moth, tobacco; larva (Ephestia elutella (Hbn.))	Moth, webbing-clothes; larva (Tineola biselliella (Hum.))	Worm, Southern Army; larva (Prodenia eridania (Cram.))	A parasite of spruce budworm; larva (Pseudosarcophaga affinis (Fall.))	Blowfly; adult (Calliphora erythrocephala Meig.)	Blowfly, black; adult (Phormia regina Meig.))	Fly, house; adult (Musca domestica L.)	Fly, Mexican-fruit; adult (Anastrepha ludens (Loew))	Fly, horse-bot; larva (Gasterophilus intestinalis (Deg.))	Fly, vinegar, fruit; adult (Drosophila melanogaster Meig.)	Mosquito, yellow-fever; larva (Aedes aegypti (L.))	Bee, honey; adult (Apis mellifera L.)	Bee, honey; larva (Apis mellifera L.)
(A)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)	(Z)	(BB)	(CC)	(DD)	(EE)	(FF)	(GG)	(HH)	(II)	(JJ)
1 Carbohydrates	50%[1]	U	U	80%[1]	50%[1]	U-Ø̸?	U	U	U	U	U	U		U	U	U	U
2 Adonitol														U			
3 Arabinose									Ø	u		Ø		U	Ø	u	
4 Arabitol														Ø			
5 Cellobiose									Ø	u		Ø		Ø	Ø?	u	
6 Cellulose																Ø̸	
7 Dextrin				U					u			U		u		Ø̸	U?
8 Dulcitol										u				Ø	U?	Ø̸	
9 Erythritol									Ø	u		Ø		Ø		Ø̸	
10 Fructose	U[5]			U	U[5]				U	U		U	U	U	U?	U	u
11 Fucose									Ø	Ø						Ø	
12 Galactose				Ø					U	U		U		u	U?	u	Ø
13 Glucose	U	U?	U3?	U	U	U[8]	U	U	U	U		U		U	U?	U	U?
14 Glycerol									u	u				U		U	
15 Glycogen									u					u			Ø
16 Hemicellulose																Ø̸	
17 Inositol						Ø			Ø	u						Ø̸?	
18 Inulin				Ø̸					Ø?					Ø		Ø̸	
19 Lactose				Ø					u	u		Ø			U?	Ø̸	Ø
20 Lyxose									Ø̸	u							
21 Maltose				U					U	U		U		U	U?	U	U
22 Mannitol				Ø					U			U		U	U?	U	
23 Mannose									U	U		U		U	U?	Ø[9]	
24 Melezitose									U	U		U		U		U	U
25 Melibiose									U	u				U		Ø̸	
26 β-Methyl fructopyranoside									Ø								
27 α-Methyl galactoside									U[2]						u		
28 β-Methyl galactoside									Ø								
29 α-Methyl glucoside				Ø					U	u				u	U?	U	
30 β-Methyl glucoside									Ø								
31 α-Methyl mannoside									Ø								
32 Raffinose				Ø					U	U		U		U	Ø	U?	
33 Rhamnose									Ø	u		Ø		Ø	Ø	u	
34 Ribose										u							
35 Sorbitol				U					U[10]	U				u	U?	U	
36 Sorbose				Ø					Ø	u					Ø	Ø	
37 Starch	Ø	Ø̸	u?	U[3]	Ø	U[5,8]	Ø		u		U			U?	U	u	Ø
38 Sucrose			U3?	Ø			U3?		U	U	U	U		U	U	U	U
39 Trehalose									U	U		U		U	u?	U	U
40 Xylose				Ø					n	u		Ø		u	u?	U3?	
41 Other polysaccharides																U	

/1/ Approximate percentage of carbohydrate required in optimum diet. /3/ Not fully utilized. /5/ Has a retarding effect on growth. /7/ Reducing sugars. /8/ Utilized but not required. /9/ Toxic for this organism. /10/ Utilized by this organism better than any other sugar.

15. UTILIZATION OF LIPIDS: INSECTS

Required (R); Not required (R̸): Utilized (U); Poorly utilized (u); Not utilized (U̸)

Lipid \ Organism	Orthoptera	Coleoptera									Lepidoptera						Diptera		
	Nymph	Larva									Larva						Larva		
	Cockroach, German (Blattella germanica (L.))	Beetle, carpet (Attagenus (sp.))	Beetle, cigarette (Lasioderma serricorne (Fab.))	Beetle, confused-flour (Tribolium confuem Duv.)	Beetle, drug-store (Stegobium paniceum (L.))	Beetle, hide (Dermestes maculatus Deg.)	Beetle, saw-toothed grain (Oryzaephilus surinamensis (L.))	Beetle, spider (Ptinus tectus Boield.)	Cowpea weevil (Callosobruchus chinensis L.)	Mealworm, yellow (Tenebrio molitor L.)	Corn borer, European (Pyrausta nubilialis (Hbn.))	Moth, fig (Ephestia cautella (Wlkr.))	Moth, Indian-meal (Plodia interpunctella Hbn.)	Moth, Mediterranean-flour (Ephestia kuehniella Zell.)	Moth, tobacco (Ephestia elutella (Hbn.))	Moth, webbing-clothes (Tinsola bisselliella (Hum.))	Fly, greenbottle (Phoenicia sericata (Meig.))	Fly, vinegar, fruit (Drosophila melanogaster Meig.)	Mosquito, yellow-fever (Aedes aegypti (L.))
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
1 Lipids, general	U		U^1	U^1	U^2	U^2	U^1	u	U	U		U^2	U^2	U^2	U^2	U	U	U	U^1
Lipids, nerve tissue																			
2 Cephalin																			U̸
3 Kerasin																			u
4 Lecithin																			u^3
5 Sphingomyelin																			u
Fats, mixed																			
6 Butter-fat												u	u	u	u		U		
7 Cod-liver oil												U		U	U				
8 Corn oil	R^4																		
9 Wheat-germ oil				U^2								U	U	$U^{2,5}$	U^1	U			
10 Yeast oil												U		U̸	U				U^2
Triglycerides																			
11 Triolein																			U̸
12 Tripalmitin																			U̸
13 Tristearin																			U̸

For footnotes, see following page.

(Continued on next page)

(For column headings, see preceding page)

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
14	Fatty Acids	∅	∅	∅	∅	∅	∅	∅	∅		∅	R[6]	R	∅	R[6]	R[6]	∅		∅	∅
15	Arachidonic acid														U[6,7,8?]					
16	Docosahexaenoic acid														∅[8]					
17	Lauric acid																			∅[9]
18	Linoleic acid											U	U[5,6]		U[5,6,10]	U[5,6]				∅
19	Linolenic acid														U[5,6]	U				∅
20	Myristic acid																			∅[9]
21	Oleic acid														∅	∅				∅[3,9]
22	Palmitic acid																			∅
23	Stearic acid																			∅
24	Sterols, derivatives	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
25	Calciferol		∅	∅	∅	∅	∅	∅?	∅		∅				∅				∅	∅
26	Cholestanol		∅	u	u?	U?	∅	U	u	U					u?				u	u
27	B-Cholestanol		∅							∅										
28	Cholestene				u?	∅	∅			U					∅					
29	Cholesterol	U[11]	U	U[2]	U[2,11]	U[2]	U[2]	U[2]	U[2]		U[2]	U[6]	U[2]	U[2]	U[2]	U[2]	U[2]	U[2]	U[2]	U[2]
30	Cholesterol, 7-dehydro-		U	U[2]	U[2]	U[2]	U[12]	U[2]	U[2]						U[2]					
31	Cholesterol, 7-hydroxy-		∅		u?	∅	∅[12]								∅					∅
32	Cholesterol dibromide		u?																	
33	Cholesteryl acetate		U		U[2]	U[2]	U[12]			∅					U[2]					
34	Cholesteryl acetate, 7-keto-		∅		∅	∅	∅[12]								∅					
35	Cholesteryl chloride		∅							∅										
36	Cholesteryl dibenzoate, 7-hydroxy-				∅?	∅	∅[12]								∅					
37	Cholesteryl monobenzoate, 7-dehydro-				u?[12]	∅	U[12]								∅					
38	Cholesteryl monobenzoate, 7-hydroxy-				u	∅	U								∅					
39	Coprosterol																			u
40	Ergosterol		u	U[2]	U[2]	U[2]	∅[12]	U[2]	U[2]		U[2]				u?				U[2]	u
41	Phytosterol									U	U[2,12]								u	
42	Sitosterol			U[2]	U[2]	U[2]	∅[12]	U[2]	U[2]	U	U[2]				U[2]				u	U[2]
43	Stigmasterol																		u	U[2]
44	Zymosterol			u[12]	∅?[12]	∅	∅[12]	U?[12]	u[12]						∅					u
45	"Tween 80"[13]																		∅	

/1/ Utilized, but reduced growth and limited metamorphosis can occur in the absence of lipids. /2/ Lipid fully utilized. /3/ Can partially replace biotin. /4/ 3% required in optimum diet. /5/ Affects wing scale formation. /6/ Alpha-tocopherol or other antioxidants required in the diet along with this constituent. /7/ Not utilized, but affects wing scale formation. /8/ Not required, but improves growth. /9/ Toxic for this organism. /10/ 0.25 - 0.5% required in optimum diet. /11/ 1% required in optimum diet. /12/ Lipid contained impurities. /13/ Sorbitan monooleate, a polyoxalkylene derivative.

16. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS: INSECTS

No insects are known to require vitamins A, C, D, or K or the provitamins of D or K. Vitamins reported to be beneficial but not required are listed as required. An entry followed by a question mark indicates the preponderance of evidence among conflicting bibliographic sources.

Required (R); Not required (✗)

Compound \ Organism	Orthoptera	Coleoptera											
	Cockroach, German[1], larva (Blattella germanica (L.))	Beetle, carpet, larva (Attagenus sp.)	Beetle, cigarette, larva (Lasioderma sericorne (Fab.))	Beetle, cigarette[2], adult (Lasioderma sericorne (Fab.))	Beetle, confused-flour, larva (Tribolium confusum Duv.)	Beetle, drug-store, adult (Stegobium paniceum (L.))	Beetle, drug-store[2], larva (Stegobium paniceum (L.))	Beetle, hide, larva (Dermestes maculatus Deg.) Also known as D. vulpinus	Beetle, red-flour, larva (Tribolium castaneum Herbst)	Beetle, saw-toothed grain, (Oryzaephilus surinamensis (L.))	Beetle, small-eyed flour, larva (Palorus ratzeburgi Wissman)	Beetle, spider, larva (Ptinus tectus Boield)	Meal worm, yellow, larva (Tenebrio molitor L.)
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)
1 Biotin	✗?	R	R?	R	R	R?	R	R	R	✗	R?	R	R
2 Carnitine[3]											R		R
3 Choline	R[4]	R	R?	R	R	✗?	R?	R		✗	R	R	✗?
4 Cobalamin[5]													
5 Vitamin E													
6 Folic acid group[6]	✗	R	✗	R	R	✗?	R	R	R		R?		R
7 Inositol	✗	✗	✗	✗	✗	✗	✗?	✗		✗	✗	✗?	✗
8 Niacin[7]	R	R	✗	R	R	✗	R	R	R	R	R	R	R
9 Pantothenic acid	R	R	✗?	R	R	✗	R	R	R	R	R	R	R
10 Para-aminobenzoic acid	✗	✗	✗?	✗	✗	✗	✗	✗		✗	✗	✗?	✗
11 Pyridoxine group[8]	R	R	✗?	R	R	✗	R	R	R	✗	R	R	R
12 Riboflavine	R	R	✗	R	R	✗	R	R	R	R	R	R	R
13 Thiamine	R	R	✗	R	R	R	R	R	R	✗	R	R	R
14 Cholesterol[9]	R	R	R	R	R	R	R	R		R		R	R
15 Linoleic acid													✗
16 Other substances	✗	✗	✗	✗	✗	✗	✗	R[10]	R	✗	✗	✗	✗

/1/ Aseptically reared on synthetic diets. /2/ Deprived of normally present intracellular symbiotes. /3/ Vitamin B_t. /4/ May be replaced by betaine. /5/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product known variously as B_{12a} or B_{12b} which has approximately the same biological activity. /6/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /7/ Used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (niacinamide). /8/ Includes pyridoxine, pyridoxal, pyridoxamine. /9/ Cholesterol may be required by all the forms listed but is shown as required only in those forms in which specific experiments have indicated its need. /10/ Unidentified substances obtained from yeast.

16. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS: INSECTS (Concluded)

No insects are known to require vitamins A, C, D, or K or the provitamins of D or K. Vitamins reported to be beneficial but not required are listed as required. An entry followed by a question mark indicates the preponderance of evidence among conflicting bibliographic sources.

Required (R); Not required (✗)

Compound \ Organism	Lepidoptera							Diptera					Hymenoptera
	Cornborer, European[1], larva (Pyrausta nubilalis (Hbn.))	Moth, Indian meal, larva (Plodia interpunctella Hbn.)	Moth, Mediterranean flour, larva (Ephestia kuehniella Zell.)	Moth, rice, larva (Corcyra cephalonica St.)	Moth, tobacco, larva (Ephestia elutella (Hbn.))	Moth, wax, larva (Galleria mellonella L.)	Moth, webbing clothes, larva (Tineola bisselliella (Hum.))	Blowfly, larva (Phoenicia sericata (Meig))	Fly, vinegar, fruit[1], larva (Drosophila melanogaster Meig.)	Mosquito, house[1], larva (Culex pipiens L.)	Mosquito, yellow-fever[1], larva (Aedes aegypti (L.))	Parasite of spruce budworm[1], larva (Pseudosarcophaga affinis (Fall.))	Bee, honey (Apis mellifera L.)
(A)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)	(Z)	(BB)
1 Biotin		R	R		R		R?	✗	R		R[11]	R	
2 Carnitine[3]									✗				
3 Choline	R		R		R		R	R	R		R	R	
4 Cobalamin[5]									✗[12]			✗	
5 Vitamin E			R										
6 Folic acid group[6]		R[13]	R[13]		R[13]			✗	✗		R	✗	
7 Inositol			R		✗		✗	✗	✗		✗?	✗	
8 Niacin[7]			R		R	R	R	R	R	✗	R	R	R
9 Pantothenic acid			R		R		R	R	R		R	✗	
10 Para-aminobenzoic acid			✗		✗		✗	✗	✗		✗?	✗	
11 Pyridoxine group[8]			R	R	R		R	R	R		R	✗	
12 Riboflavine			R	R	R		R	R	R	R	R	R	R
13 Thiamine			R	R	R	R	R	R	R	R	R	R	
14 Cholesterol[9]		R	R	R	R			R	R		R		
15 Linoleic acid		✗	R		R								
16 Other substances	R[14]	R[10]	✗?	R[10]	✗?	✗	✗			R[15]	R[16]	R	R[10]

/1/ Aseptically reared on synthetic diets. /3/ Vitamin B_t. /5/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product known variously as B_{12a} or B_{12b} which has approximately the same biological activity. /6/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (Folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /7/ Used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (niacinamide). /8/ Includes pyridoxine, pyridoxal, pyridoxamine. /9/ Cholesterol may be required by all the forms listed but is shown as required only in those forms in which specific experiments have indicated its need. /10/ Unidentified substances obtained from yeast. /11/ May be partially replaced by lecithin oil from hydrolized plasma (FSF)or oleic acid. /12/ Cobalamin addition produces higher percentage of pupation. /13/ May be replaced by an increased amount of xanthopterin. /14/ Unidentified substance obtained from yeast and cornleaves. /15/ Unidentified substances obtained from yeast or liver. /16/ Glutathione and unidentified substance obtained from yeast and liver.

17. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS: PROTOZOA

Required (R); Not Required (⌀)

Vitamins and Related Substances \ Species	Ciliata									Flagellata																				Sarcodina	Sporozoa
	Colpidium campylum	C. striatum	Colpoda duodenaria	Glaucoma scintillans	Paramecium aurelia[1]	P. multimicronucleateum	Pleurotricha lanceolata	Stylonichia pustulata	Tetrahymena piriformis	Eutrichomastix colubrorum	Leishmania agamae	L. ceramodactyli	L. donovani	L. tropica	Leptomonas ctenocephali	L. pyrrhocoris	Strigomonas culicidarum[2]	S. culicidarum[3]	S. fasciculata	S. media	S. muscidarum	S. oncopelti	S. parva	Trichomonas batrachorum	T. columbae	T. foetus	T. gallinarum	T. vaginalis	Trypanosoma cruzi	Acanthamoeba castellani	Plasmodium knowlesi
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)	(Z)	(BB)	(CC)	(DD)	(EE)	(FF)	(GG)
1 Vitamin A																															
2 Ascorbic acid			⌀						⌀	R	⌀	⌀	R	R	⌀	⌀	⌀	⌀	⌀	⌀	⌀	⌀	⌀	⌀	R	R	R		R	⌀	
3 Biotin			⌀						⌀																						
4 Choline									⌀																						
5 Cobalamin[4]																															
6 Vitamin D																															
7 Vitamin E																															
8 Folic acid group[5]					R																										
9 Inositol			⌀						⌀																						
10 Vitamin K																															
11 Niacin[6]			R						R																						
12 Pantothenic acid			R						R																						
13 Para-aminobenzoic acid			⌀						⌀																						
14 Pyridoxine group[7]			R						R																						R
15 Riboflavine	R		R		R				R																						
16 Thiamine	R	R	R	R	R				⌀								R	R	R			R								R	
Other growth factors																															
17 Cholesterol			⌀						⌀	R															R	R					
18 Hematin			⌀						⌀		R	R	R	R	R	R	R	⌀	R	⌀	R	⌀	⌀						R		
19 Unidentified	R		R	R	R[8]	R	R	R	R[9]	R	R		R	R	R		R	⌀	R	⌀	R	⌀	⌀	R	R	R	R		R		R

/1/ Var. 4, Stock 51.7 (sensitive). /2/ Subspecies anophelis. /3/ Subspecies culicis. /4/ A generic term including cyancobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /5/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U,L. casei factor, Norite eluate factor. /6/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P.P.) factor, antiblacktongue factor. /7/ Includes pyridoxine, pyridoxal, pyridoxamine. /8/ Steroid of stigmasterol and sitosterol groups, also brassicasterol. /9/ Reported as α-lipoic acid.

18. CORRELATION OF NUTRIENT REQUIREMENTS WITH BODY WEIGHT, ENERGY METABOLISM, AND FOOD INTAKE: ANIMALS

Values are for adult forms, in the resting or near-resting state, and under ordinary (i.e., non-stress) environmental conditions.

	Nutrient	Requirement				
		Per kg Body Weight per day	Per kg $Body\ Weight^{0.75}$ per day[1]	Per sq m Body Surface per day	Per kg Food Intake[2]	Per Calorie[3]
		µg	mg	mg	mg	
	(A)	(B)	(C)	(D)	(E)	(F)
1	Vitamin A[4]	5				
2	Carotene	30				
3	Ascorbic acid	70005				
4	Protein[6], digestible		1660	20,825		
5	Calcium[7]		29	373		
6	Phosphorus[8]		59	746		
7	Water					1 ml
8	Iodine					0.03-0.04 µg
9	Thiamine				1	
10	Riboflavine				1.5	
11	Pyridoxine				2	
12	Pantothenic acid				5	
13	Niacin[9,10]				10	
14	Cobalt				0.07	
15	Copper				3-5	
16	Calories[3], utilizable, basal energy expenditure		66	833		
17	Total calories[3], utilizable, very light muscular activity[11]		99[12]	1249[13]		

/1/ "Metabolic body size". /2/ Food of low fat content weighed moisture free. Values 9-13 E inclusive do not apply to the ruminant because of the synthesis of vitamins by the microorganisms of the rumen. Values 14,15 E apply to ruminants only. /3/ Kilocalories. /4/ Requirement for vitamin A may be satisfied by vitamin A or carotene, efficiency of conversion apparently varies with different species. /5/ This value applies to guinea pigs only. /6/ Assuming a biological value of 50. /7/ Assuming a utilization of dietary calcium of 30%. /8/ Assuming a utilization of dietary phosphorus of 30%. Phosphorus may also be required in proportion to the amount of dry food consumed. /9/ Nicotinic acid (niacin); nicotinic acid amide (nicotinamide). /10/ Decreases with increasing protein (tryptophan) intake. /11/ Muscular activity at rate of 0.5 x basal, plus basal Calories = total Calories utilizable. /12/ i.e., 33 Calories (0.5 x basal), plus 66 Calories (basal) = 99 total Calories utilizable/kg body $weight^{0.75}$ per day. /13/ i.e., 416 Calories (0.5 x basal) plus 833 Calories (basal) = 1249 total Calories utilizable/sq m body surface/day.

19. CHEMICAL ELEMENT COMPOSITION OF NUTRIENT SOLUTIONS: HIGHER PLANTS

The nutrients listed, together with carbon supplied by CO_2 absorbed directly from the atmosphere and hydrogen derived from the water in the solution, are sufficient for satisfactory growth of most higher plant forms so far tested. Wide differences in concentration of the nutrients have been found to be permissible. The solution is renewed at intervals to avoid depletion.

	Elements[1]	Hoagland, D.R. and Arnon, D.I., 1950[2]		Robbins, W.R., 1952[3]	
		Composition of Nutrient Solutions			
		mAt/L[4]	mg/L	mAt/L[4]	mg/L
	(A)	(B)	(C)	(D)	(E)
1	Boron	0.046	0.5	0.009	0.1
2	Calcium	5	200	5	200
3	Chlorine[5]	0.018	0.65		
4	Copper	0.0003	0.02	0.00016	0.01
5	Iron	0.018[5]	1.0[5]	0.009	0.5
6	Magnesium	2	49	2	49
7	Manganese	0.009	0.5	0.0045	0.25
8	Molybdenum	0.0001	0.01	0.0001	0.01
9	Nitrogen[6]: from NH_4[7]	1	14	0	0
10	Nitrogen[6]: from NO_3	14	196	10	140
11	Oxygen[8]		6		6
12	Phosphorus	1	31	1	31
13	Potassium	6	235	5	195
14	Sulfur	2.03	65	4.02	129
15	Zinc	0.0008	0.05	0.0008	0.05

/1/ For compounds used in making solutions, see table 57, Composition of Nutrient Solutions: Higher Plants. /2/ This solution has been found satisfactory for growth of over 40 higher plant forms tested, including tomato, corn, asparagus, sequoia seedlings, etc. /3/ This solution has been found satisfactory for a wide variety of higher plant species including fruit, vegetable, ornamental, field crop, silvicultural, and non-cultivated forms (citrus, tomato, rose, tobacco, spruce, etc.). /4/ Milligram-atoms per liter. /5/ Not known to be essential to plant nutrition. /6/ Where environmental conditions (temperature, light) promote rapid growth, a solution high in nitrogen should be used. For light intensity over 5000 foot candles, up to 350 mg total N per liter. /7/ Nitrogen in the form of ammonium ion is supplied in small quantity to aid in the maintenance of a favorable pH range. Ammonium ion is not otherwise needed, as such, in nutrient solutions. /8/ Not included in solution formula as published, but required (in solution) for satisfactory growth. Value estimated from solubility of atmospheric oxygen in water. Must be continuously replenished by aeration when roots are constantly submerged in solution.

20. UTILIZATION OF CHEMICAL ELEMENTS: CORN PLANT

Values indicate the amount of various elements used in the growth of one acre (0.4 hectare) of corn plants producing at the rate of 100 bushels per acre. They represent analys s made in Illinois and Indiana during 1935-1940. Where a range is given, the lower value presents observations from corn plants grown in Indiana; the upper value, for plants grown in Illinois. All other values are applicable to both localities. There were approximately 12,000 plants per acre (30,000 plants per hectare) and the production of shelled corn was at the rate of 5,600 pounds per acre (6,300 kg per hectare).

	Element[1]	Quantity Utilized	
		lb/Acre[2]	kg/hectare
	(A)	(B)	(C)
1	Oxygen	6800	7620
2	Carbon	5200	5830
3	Nitrogen	130-160	150-180
4	Potassium	110-125	120-140
5	Sulfur	22-75	24-84
6	Magnesium	33-50	37-56
7	Calcium	37-50	41-56
8	Phosphorus	22-40	25-45

	Element[1]	Quantity Utilized	
		lb/Acre[2]	kg/hectare
	(A)	(B)	(C)
9	Iron	2	2.2
10	Manganese	0.3	0.34
11	Boron	0.06	0.06
12	Chlorine	Trace	Trace
13	Iodine	Trace	Trace
14	Zinc	Trace	Trace
15	Copper	Trace	Trace

/1/Data for water utilized: 4,300,000 to 5,500,000 pounds per acre(4,820,000 to 6,165,000 kg per hectare). /2/ Pounds per acre x 1.121 = kg per hectare.

21. UTILIZATION OF NUTRIENTS: LOWER ALGAE AND RELATED COLORLESS ORGANISMS

Oxygen is essential for all these organisms. Carbon dioxide is required by all the species in this table for which data are available. Colorless forms and green forms when grown in darkness need an additional carbon source. Such additional carbon sources may stimulate growth of green forms in light under certain conditions.

Utilized (U); Poorly Utilized (u); Not Utilized (∅); Required (R); Not Required (∄); Questionable (?)

Nutrient \ Organism	Photosynthetic Forms														Colorless Forms									
	Chlamydomonas agloëformis	C. moewusii	Chlorogonium elongatum	C. euchlorum	Euglena anabaena minor	E. deses1	E. gracilis typica	E. gracilis bacillaris	E. gracilis urophora	E. klebsii[2]	E. pisciformis	E. stellata	Haematococcus pluvialis	Nitzschia closterium	Astasia longa[3]	A. quartana	Chilomonas paramecium	Hyalogonium klebsii	Polytoma caudatum	P. obtusum	P. ocellatum	P. uvella	Polytomella caeca	Prototheca zopfii
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)
Vitamins																								
1 Cobalamin[4]	∄	∄	∄	∄	∄[5]		R[6]	R[6]	R[6]	R[5]		∄?[5]	∄	∄	R		∄							
2 Thiamine	∄	∄	∄	∄	∄[5]		R[7]	R	R	R[5]	R[8]	∄?[5]	∄	∄	R		R[8]		R[9]	∄	R[9]	∄	R[8]	R[8]
3 Other	∄	∄	∄	∄	∄[5]					?		∄?[5]	∄	∄	∄		∄			∄		∄		
Carbon Source: Sugars																								
4 Arabinose		∅	U?	∅?			∅										∅?					∅		∅
5 Glucose		∅	∅?	∅?	∅	∅	∅	U	∅	∅	∅				∅		∅?				∅	∅	∅	U
6 Maltose		∅	∅?	∅?													∅?						∅	∅
7 Sucrose		∅	U?	∅?	∅	∅	∅			∅	∅						∅?						∅	∅
8 Xylose		∅	∅?	∅?													∅?					∅		∅
Carbon Source: Organic Acids (Other Than Fatty Acids)[10]																								
9 Citric	∅	∅			∅	∅	∅	∅	∅	∅			∅							∅				∅
10 Fumaric		∅						U	U															∅
11 Lactic	∅	∅		∅	∅		U	∅	U			∅	∅		U?	U	U	∅	∅	∅	U	U?	∅?	U[11]
12 Malic	∅	∅		∅	∅	∅	U	U	U	∅	∅		∅		U?	∅	∅	∅		∅	∅?	∅	∅	
13 Phosphoglyceric	∅	∅			∅	∅	∅	U			∅		∅							∅				
14 Pyruvic		∅		u	∅	∅	U		U		∅	∅			∅?	u	U	∅	U	u	U	u	u	U[11]
15 Succinic	∅	∅		U	∅	∅	U	U	∅?		∅		∅		U?	U	u	U		∅	∅?	U?	u	∅
Carbon Source: Alcohols[12]																								
16 i-Butanol							∅		U						u		∅		∅	∅	U	∅	U	U
17 n-Butanol		∅					U		U						U	∅	U		∅	∅	U	∅	U	U
18 Ethanol		∅	∅	∅		U	U		U						U	∅	U	∅	∅	∅	U	∅	U	U
19 Glycerol		∅			∅	∅					∅	∅												U
20 n-Hexanol							U		U						U	∅	U				U		U	
21 Methanol							∅		∅						∅	∅	∅		∅	∅	∅	∅	∅	∅
22 i-Pentanol							∅		∅						∅		∅				∅		∅	u
23 n-Pentanol							∅		∅						∅		u[13]		∅	∅	u	∅	∅	U
24 i-Propanol							∅		∅						∅		∅		∅		∅	∅	∅	∅
25 n-Propanol							U		U						U	∅	u[13]		∅	∅	U	∅	U	U
Carbon Source: Fatty Acids[14]																								
26 Acetic	U	∅	U	U	∅	∅	U	U	U	∅	∅	∅	U		U	U	U	U	U	U	U	U	U	U

/1/ According to E. G. Pringsheim, the organism used in these studies was E. geniculata. /2/ According to E. G. Pringsheim, the organism used in these studies was E. mutabilis. /3/ Syn. A. chattoni (A. Lwoff, 1936) or A. klebsii (H. von Dach, 1940). /4/ A generic term including cyancobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /5/ It has been reported that the organism requires no vitamins, but it is possible that this comes about only after adaptation to vitamin-less media, as with other species of Euglena. /6/ The organism utilizes also pseudo-cobalamin. /7/ Can be replaced by pyrimidine. /8/ Can be replaced by pyrimidine and thiazole. /9/ Can be replaced by thiazole. /10/ Negative results reported for organic acids may not be significant since it has been shown that Prototheca zopfii and Euglena gracilis utilize them only at pH 3.5-5.5. Most of the negative results tabulated were obtained in media having a pH near neutrality. /11/ Utilized only at pH 3.0-5.5. /12/ Optimal concentrations are similar to those of the corresponding fatty acid (cf. Fn 14). /13/ Inadequate for growth in a mineral medium. /14/ The average range of concentration, in grams per 100 ml of media, at which fatty acids are utilized and non-toxic is the following: acetic, propionic, butyric and isobutyric acids, 0.1-0.2; valeric and isovaleric acids, 0.05-0.1; caproic, isocaproic, heptylic and octylic acids, 0.01-0.03; nonylic acid, 0.01; decyclic acid, 0.005-0.008. Some of the negative results tabulated may be incorrect if toxic concentrations were employed. In general, toxicity increases with the length of the chain of carbon atoms and with the decrease in the pH of the medium.

21. UTILIZATION OF NUTRIENTS: LOWER ALGAE AND RELATED COLORLESS ORGANISMS (Concluded)

Oxygen is essential for all these organisms. Carbon dioxide is required by all the species in this table for which data are available. Colorless forms and green forms when grown in darkness need an additional carbon source. Such additional carbon sources may stimulate growth of green forms in light under certain conditions.

Utilized (U); Poorly Utilized (u); Not Utilized (Ø); Required (R); Not Required (Ø); Questionable (?)

	Organism / Nutrient	Photosynthetic Forms													Colorless Forms									
		Chlamydomonas agloëformis	C. moewusii	Chlorogonium elongatum	C. euchlorum	Euglena anabaena minor	E. deses[1]	E. gracilis typica	E. gracilis bacillaris	E. gracilis urophora	E. klebsii[2]	E. pisciformis	E. stellata	Haematococcus pluvialis	Nitzschia closterium	Astasia longa[3]	A. quartana	Chilomonas paramecium	Hyalogonium klebsii	Polytoma caudatum	P. obtusum	P. ocellatum	P. uvella	Polytomella caeca	Prototheca zopfii
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)
	Carbon Source: Fatty Acids[14] (Concluded)																								
27	1-Butyric	Ø		Ø	Ø	Ø	Ø	Ø		U		Ø		Ø		u	u	Ø	Ø	Ø	Ø	U	Ø	Ø	U
28	n-Butyric	U	Ø	U	Ø	Ø	Ø	U	U	U	Ø	Ø		U		U	U	Ø	Ø	U	U	U	U	U	U
29	1-Caproic							u		u						u	U	U		Ø	Ø	U	U	u	U
30	n-Caproic	Ø		Ø	Ø	Ø	Ø[15]	U		U		Ø[15]		Ø		U	U	U	Ø	Ø	Ø	U	U	U	U
31	n-Decylic							U		u						u				Ø	Ø	U	Ø	U	U
32	n-Heptylic					Ø[15]	Ø[15]	Ø		U		Ø[15]				U	U	u		Ø	Ø	U	Ø	U	U
33	n-Nonylic					Ø[15]	Ø[15]	U		u		Ø[15]				U		U		Ø	Ø	U	Ø	U	U
34	n-Octylic					Ø[15]	Ø[15]	U		U		Ø[15]				U		U		Ø	Ø	U	u	U	U
35	Propionic	Ø	Ø	Ø	Ø	Ø	Ø	U		U	Ø	Ø	Ø	Ø		U	U	Ø	Ø	Ø	Ø	U	Ø	U	U
36	1-Valeric					Ø	Ø	Ø		Ø		Ø				Ø	u	u		Ø	Ø	u	Ø	Ø	u
37	n-Valeric	Ø	Ø	Ø	Ø	Ø	Ø	U		U		Ø		Ø		U	U	U	Ø	Ø	Ø	U	U	U	U
	Nitrogen Sources[16]																								
38	D-Alanine					U	U	U[17]	U[17]		U	Ø[18]	U								u	U	Ø		
39	Ammonium	U	U	U	U	U	Ø	U[17]	Ø[17]	U[17]	u	U[18]	U	U	U	U		U		U	U	U	U	U	U
40	D-Arginine					Ø	Ø	Ø			Ø	Ø[18]	U								u				
41	L-Asparagine	U[17]	U		U[17]	U	U	U[17]			U	U[19]	U	U[17]						U	U		U		
42	D-Glutamic Acid[20]					Ø	U	U[17]	U[11,17]	U[11,17]	U	Ø[18]	U		U										
43	Glycine	U[17]				U	Ø	U[17]			U	Ø[18]	U	U[17]							U		U		
44	Histidine					Ø	Ø	U[17]			U	Ø[18]	U								u		u		
45	L-Leucine					U	U	U[17]			U	Ø[18]	U								u		Ø		
46	D-Lysine					Ø	U	Ø			U	Ø[18]	U								u				
47	Nitrate	U	U	U	U	U	Ø	u	Ø	Ø	u	Ø[18]	U	u	U			?		Ø	Ø	U	Ø	Ø	
48	Peptone	U[17]	U	U[17]	U[17]	U	U	U[17]	U[17]	U[17]	U	U	U	U[17]	U	U	U	U	U	U	U	U	U	U	U
49	DL-Phenylalanine					U	Ø	U[17]			Ø	Ø[18]	U								u				
50	DL-Proline					U	U	U[17]			U	Ø[18]	U								u				
51	DL-Serine					Ø	u	U[17]			U	Ø[18]	U								u		u		
52	L-Tryptophan					Ø	Ø	Ø			Ø	Ø[18]	Ø								u				
53	L-Tyrosine					Ø	Ø	Ø			Ø	Ø[18]	Ø												
54	DL-Valine					U	Ø	U[17]			U	Ø[18]	U										u		

/1/ According to E. G. Pringsheim, the organism used in these studies was E. geniculata. /2/ According to E. G. Pringsheim, the organism used in these studies was E. mutabilis. /3/ Syn. A. chattoni (A. Lwoff, 1936) or A. klebsii (R. von Dach, 1940). /14/ The average range of concentration in mg, per 100 ml of media, at which fatty acids are utilized and non-toxic is the following: acetic, propionic, butyric and isobutyric acids, 0.1-0.2; valeric and isovaleric acids, 0.05-0.1; caproic, isocaproic, heptylic and octylic acids, 0.01-0.03; nonylic acid, 0.01; decylic acid, 0.005-0.008. Some of the negative results tabulated may be incorrect if toxic concentrations were employed. In general, toxicity increases with the length of the chain of carbon atoms and with the decrease in the pH of the medium. /15/ Acid employed at toxic concentrations. /16/ Colorless forms utilize the same nitrogen sources in light as in darkness. For photosynthetic forms, data pertain to utilization in light; the same nitrogen sources which are utilized in darkness are indicated by Fn 18. Some of the amino acids listed may, where utilized, also serve as a carbon source for some organisms. /17/ Also utilized in darkness. /18/ Negative results may not be valid because tests were conducted in a medium lacking thiamine. /19/ Growth is obtained only if thiamine is present. /20/ When utilized, it is a good carbon source.

22. AMINO ACID REQUIREMENTS: BACTERIA

Required (R); Not Required (✗)

	Organism / Amino Acid	Aerobacter aerogenes	Bacillus alvei	B. anthracis	B. brevis	B. cereus	B. cereus var. mycoides	B. circulans	B. coagulans	B. licheniformis	B. macerans	B. megaterium	B. pasteurii	B. polymyxa	B. pumilus	B. sphaericus	B. subtilis	B. subtilis var. niger	Brucella abortus	B. melitensis
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
1	Alanine	✗								✗	✗	✗		✗	✗		✗	✗		
2	Arginine	✗								✗	✗	✗		✗	✗		✗	✗		
3	Aspartic acid																			
4	Citrulline	✗								✗	✗	✗		✗	✗		✗	✗		
5	Cystine	✗								✗	✗	✗		✗	✗		✗	✗		
6	Glutamic acid	✗								✗	✗	✗		✗	✗		✗	✗		
7	Glycine	✗								✗	✗	✗		✗	✗		✗	✗		
8	Histidine	✗								✗	✗	✗		✗	✗		✗	✗		
9	Hydroxyproline	✗								✗	✗	✗		✗	✗		✗	✗		
10	Isoleucine	✗								✗	✗	✗		✗	✗		✗	✗		
11	Leucine	✗								✗	✗	✗		✗	✗		✗	✗		
12	Lysine	✗								✗	✗	✗		✗	✗		✗	✗		
13	Methionine	✗								✗	✗	✗		✗	✗		✗	✗		
14	Norleucine	✗								✗	✗	✗		✗	✗		✗	✗		
15	Proline	✗								✗	✗	✗		✗	✗		✗	✗		
16	Serine	✗								✗	✗	✗		✗	✗		✗	✗		
17	Threonine	✗								✗	✗	✗		✗	✗		✗	✗		
18	Tryptophan	✗								✗	✗	✗		✗	✗		✗	✗		
19	Tyrosine	✗								✗	✗	✗		✗	✗		✗	✗		
20	Valine	✗								✗	✗	✗		✗	✗		✗	✗		
21	Amino acids, unspecified		R	R	R	R	R	R	R	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R	R[2]	R[2]	R[1]	R[1]
22	Other Nitrogen source	R																		

/1/ Certain strains; other strains have no known requirement. /2/ As NH_3; varies in case of B. pasteurii.

22. AMINO ACID REQUIREMENTS: BACTERIA

Required (R); Not Required (✗)

Amino acid \ Organism	Brucella suis	Erwinia amylovora	E. spp.[3]	E. tracheiphila	Escherichia coli	Lactobacillus arabinosus 17-5	L. (hetero-fermentative)	Leuconostoc citrovorum	L. dextranicum	L. mesenteroides	Pasteurella miltocida	P. pestis	P. tularense	Proteus morgani	Salmonella cholerae-suis[4]	S. typhosa	Serratia marcescens	Shigella paradysenteriae	S. sonnei
(A)	(U)	(V)	(W)	(X)	(Y)	(Z)	(BB)	(CC)	(DD)	(EE)	(FF)	(GG)	(HH)	(II)	(JJ)	(KK)	(LL)	(MM)	(NN)
1 Alanine	✗	✗	✗	✗	✗	✗				R							✗		✗
2 Arginine	✗	✗	✗	✗	✗	R				R							✗		✗
3 Aspartic acid						✗				R									
4 Citrulline	✗	✗	✗	✗	✗	✗				✗							✗		✗
5 Cystine	✗	✗	✗	✗	✗	R				R			R	R			✗		✗
6 Glutamic acid	✗	✗	✗	✗	✗	R				R							✗		✗
7 Glycine	✗	✗	✗	✗	✗	✗				R							✗		✗
8 Histidine	✗	✗	✗	✗	✗	✗				R							✗		✗
9 Hydroxyproline	✗	✗	✗	✗	✗	✗				✗							✗		✗
10 Isoleucine	✗	✗	✗	✗	✗	R				R							✗		✗
11 Leucine	✗	✗	✗	✗	✗	R				R							✗		✗
12 Lysine	✗	✗	✗	✗	✗	R?				R							✗		✗
13 Methionine	✗	✗	✗	✗	✗	R				R							✗		✗
14 Norleucine	✗	✗	✗	✗	✗	✗				✗							✗		✗
15 Proline	✗	✗	✗	✗	✗	✗				R							✗		✗
16 Serine	✗	✗	✗	✗	✗	✗				R							✗		✗
17 Threonine	✗	✗	✗	✗	✗	R				R							✗		✗
18 Tryptophan	✗	✗	✗	✗	✗	R		R	R	R						R[1]	✗		✗
19 Tyrosine	✗	✗	✗	✗	✗	R				R					R[5]		✗		✗
20 Valine	✗	✗	✗	✗	✗	R				R							✗		✗
21 Amino acids, unspecified	R[1]					R[6]	R[6]	R[7]	R[7]	R[7]	R	R[8]	R		R[5]	R		R[6]	R[6]
22 Other Nitrogen source		R[2]	R[2]	R[2]	R[2]												R[2]		R[2]

/1/ Certain strains; other strains have no known requirement. /2/ As NH_3. /3/ Various species of soft rot group. /4/ Ammonium sulfate or asparagine usually suffice, but tyrosine or other amino acids occasionally required. /5/ Applies also to S. enteritidis, S. gallinarum, S. pullorum, and S. schottmuelleri. /6/ Requirement varies. /7/ Incompletely known. /8/ 10 or more.

23. UTILIZATION OF SUGARS FOR GROWTH: FILAMENTOUS FUNGI

Interpretation of the amount of growth obtained on different sugars is often subject to error. Low yields may be due to slow utilization of the sugar involved, but are frequently due to other factors. It is possible that some organisms listed as not utilizing (∅) a certain sugar, or utilizing it poorly (u) will be found to utilize it well (U) under different nutritional conditions.

Utilized (U); Utilized slowly (u); Utilization slight or none (∅)

	Species \ Sugar	D-Glucose	D-Fructose	D-Mannose	D-Galactose	L-Sorbose	L-Arabinose	D-Xylose	Maltose	Sucrose	Lactose	Cellobiose	Raffinose
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
1	Achlya flagellata	U	∅	∅	∅		∅	∅	U	U	∅		∅
2	Alternaria solani	U	U	U	U	u	U	U	U	U	u	u	u
3	Aspergillus clavatus	U	U	U	U	∅	U	U	U	U	u	U	U
4	A. elegans	U	U	U	u	u	U	U	U	U	u	u	U
5	A. niger	U	U	U	u	U	u	U	U	U	u		
6	A. oryzae	U	U	U	U		u	u	U		∅		u
7	A. rugulosus	U	U	U	U	u	U	U	U	U	u	u	U
8	Blakeslea trispora	U	U	U	U				U	u	u		
9	Blastocladia pringsheimii	U	U	U	∅	∅	∅	∅	U	U	∅		
10	Botrytis cinerea	U	U	U	U	U	U	U	U	U	U	U	U
11	Ceratostomella fimbriata	U	u	U	u	∅	u	u	U	U	∅	u	∅
12	Chaetomium convolutum	U	u	U	U	∅	U	U	U	U	u	U	∅
13	C. globosum	U	U	U	U	u	u	u	U	U	u	u	u
14	Choanephora cucurbitarum	U	U	U	U	∅	u	u	U	∅	∅	U	∅
15	Coccidioides immitis	U	U	U	U		∅	u	U	∅	∅	U	u
16	Colletotrichum lindemuthianum	U	U	U	U	∅	u	u	U	U	U	U	U
17	Collybia velutipes	U	U	U	u	∅	u	u	U	U	u	U	u
18	Cordyceps militaris	U	U	U	U	∅	u	U	U	u	∅	U	u
19	Dendrophoma obscurans	U			u	∅			U	U	∅		
20	Diaporthe phaseolorum batat.	U	U						U	U	U		
21	Dictyuchus monosporus	U	∅	∅	∅		∅	∅	∅	∅	∅		∅
22	Diplodia macrospora	U	U	U	U				U	U	u		
23	D. natalensis	U	U	U	u				U	U	u		
24	Endoconidiophora fagacearum[1]	U	u	U	u	∅	u	u	u	U	∅	U	u
25	Endothia parasitica	U	U	U	u	u	u	u	U	U	∅	U	U
26	Entomophthora apiculata	U	u	U	u	u	∅	∅	∅	∅	∅	∅	∅
27	E. coronata	U	U	U	u	∅	∅	∅	∅	∅	∅	∅	∅
28	Fusarium conglutinans	U	U	U	U	u	U	U	U	U	u	u	u
29	F. culmorum	U	U	U	U	u	u	u	u	u	u	U	U
30	F. lycopersici	U	U	U	U	U	U	U	U	U	u	u	u
31	F. medicaginis	U	U	U	U	u	U	U	U	U	u	u	U
32	F. nivale	U	U	U	U	u	U	U	U	U	u	U	U
33	F. niveum	U	U	U	U	U	U	U	U	U	U	U	U
34	F. tracheiphilum	U	U	U	U	u	U	U	U	u	U	u	U
35	Glomerella cingulata	U	U	U	U	u	U	U	U	U	u	U	U
36	Helicostylum pyriforme	U	U	U	U				U	u	u		
37	Helminthosporium sativum	U	U	U	u	u	u	u	U	U	u	u	u
38	Lenzites saepiaria	U	U	U	u	u	∅	u	U	u	u	∅	∅
39	L. trabaea	U	u	U	u	u	u	u	U	u	U	U	u
40	Leptomitus lacteus	∅	∅		∅				∅	∅			

/1/ Formerly Chalara quercina.

23. UTILIZATION OF SUGARS FOR GROWTH: FILAMENTOUS FUNGI (Concluded)

Interpretation of the amount of growth obtained on different sugars is often subject to error. Low yields may be due to slow utilization of the sugar involved, but are frequently due to other factors. It is possible that some organisms listed as not utilizing (∅) a certain sugar, or utilizing it poorly (u) will be found to utilize it well (U) under different nutritional conditions.

Utilized (U); Utilized slowly (u); Utilization slight or none (∅)

	Species \ Sugar	D-Glucose	D-Fructose	D-Mannose	D-Galactose	L-Sorbose	L-Arabinose	D-Xylose	Maltose	Sucrose	Lactose	Cellobiose	Raffinose
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
41	Melanconium fuligineum	U	U	U	U	u	u	u	U	U	∅	U	u
42	Memnoniella echinata	U	U	U	U		U	U	U	U	U	U	U
43	Monilinia fructosa	U	U	U	U	U	u	U	U	U	∅	U	u
44	Monosporium apiospermum	U	U	U	U	∅	u	U	u	U	u	u	u
45	Mucor ramannianus	U	U	U	U	u	u	U	U	∅	U	U	∅
46	Neocosmospora vasinfecta	U	U	U	U	∅	U	U	U	U	u	u	u
47	Ophiobolus graminis	U	u	U	U	∅	u	u	U	U	u	u	u
48	Penicillium chrysogenum	U	U	U	U	u	U	U	U	U	u	u	U
49	P. digitatum	U	U	U	U		U	U	u	U	U	U	
50	P. expansum	U	U	U	U	u	u	U	U	U	∅	U	U
51	P. spiculosporum	U	U	U	U	u	U	U	U	U	∅	U	u
52	Phoma betae	U	U	U	U	u	U	U	U	U	u	U	U
53	Phycomyces blakesleeanus	U	U	U	u	∅	u	U	U	U	∅	u	∅
54	Phymatotrichum omnivorum	U	U	U	∅			∅	U	U	u		u
55	Phytophthora cactorum	U	u	u	∅				U	U	∅		
56	P. erythroseptica	U	u	U	∅				U	U	∅		
57	P. fagopyri	U	u	u	∅				u	U	∅		
58	P. infestans	U	U	u	∅	∅	∅	∅	u	u	∅	∅	∅
59	Pilaira moreaui	U	U	U	U				U	u	U		
60	Polyporus albellus	U	u	U	u	∅	u	U	U	∅	∅	u	∅
61	P. versicolor	U	U	U	u	u	U	u	U	U	u	U	u
62	Pythiogeton uniforme	U	U		∅		∅	U	U	U	u	U	
63	Pythiomorpha gonapodyoides	U	U	u	∅				u	U	∅		
64	Pythium ascophallon	U	u	U	∅				U	U	∅		
65	Rhizophlyctis rosea	U	∅	∅	∅	∅	∅	∅	∅	∅	∅	U	
66	Rhizopus nigricans	U	U	U	U				U	∅	∅		
67	R. suinus	U	U	U	U				u	∅	∅		
68	Rosellinia arcuata	U	U	U	u				U	u	u		
69	Saprolegnia delica	U	U	∅	∅		∅	∅	U	∅	∅		∅
70	S. ferax	U	∅	∅	∅		∅	∅	U	∅	∅		∅
71	Schizophyllum commune	U	U	U	u	∅	u	u	u	u	u	u	u
72	Schizothecium longicolle	U	U	U	∅	∅	∅	U	U	∅	∅	U	∅
73	Sclerotium delphinii	U	U				U	U	U	U			
74	Septoria nodorum	U			u	∅			u	u	u		
75	Sordaria fimicola	U	U	U	u	∅	u	u	U	u	u	U	∅
76	Sphaeropsis malorum	U	U	U	U	u	u	u	U	U	u	U	u
77	Stysanus stemonitis	U	u	U	U	∅	U	u	U	U	U	U	U
78	Syncephalastrum racemosum	U	U	U	U	∅	u	u	U	∅	∅	u	u
79	Thielavia basicola	U	U	U	U				U	U	∅		
80	Thraustotheca clavata	U	∅	∅	∅		∅	∅	U	U	∅		∅
81	Typhula variabilis	U	U	U	u				U	U	∅		
82	Ustilago violacea	U	U	U	U		∅	∅	U	U	∅	U	∅

24. UTILIZATION OF CARBOHYDRATES: YEASTS

Utilized (U); Not Utilized (∅); Variable (u)

	Carbohydrates and related substances \ Yeast	Candida albicans	C. guilliermondii	C. krusei	C. lipolytica	C. parapsilosis	C. pulcherrima	Debaryomyces globosus[1]	Hansenula anomala	H. californica	H. canadensis	H. capsulata	H. jadinii	H. mrakii	H. saturnus	H. silvicola	H. suaveolens
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
1	D-Arabinose	∅	U	∅	∅	∅	∅	∅	∅	∅	∅	u	∅	∅	∅	∅	∅
2	L-Arabinose	u	U	∅	∅	U	∅	∅	u	∅	∅	U	∅	∅	∅	U	∅
3	Cellobiose	∅	U	∅	∅	∅	U	∅	U	U	U	U	U	U	U	U	U
4	Dulcitol	∅	U	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅
5	i-Erythritol	∅	∅	∅	U	∅	∅	∅	U	∅	∅	U	∅	∅	∅	∅	∅
6	Ethyl alcohol	∅	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
7	Galactose	U	U	∅	u	U	U	∅	u	∅	∅	∅	∅	∅	∅	U	∅
8	Glucose	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
9	Glycerol	u	U	U	U	U	U	u	U	U	U	U	U	U	U	U	U
10	Inulin	∅	U	∅	∅	∅	∅	u	∅	∅	∅	∅	U	∅	U	∅	U
11	Lactose	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	u	∅	∅	∅	∅	∅
12	Maltose	U	U	∅	∅	U	U	∅	U	u	U	U	U	∅	∅	U	∅
13	D-Mannitol	U	U	∅	U	U	U	U	U	U	U	U	U	U	u	u	U
14	Melezitose	U	U	∅	∅	U	U	∅	U	∅	U	U	U	∅	∅	u	∅
15	Melibiose	∅	U	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅
16	Raffinose	∅	U	∅	∅	∅	∅	U	U	∅	∅	∅	U	∅	U	∅	U
17	L-Rhamnose	∅	U	∅	∅	∅	∅	∅	∅	U	U	U	∅	U	U	U	∅
18	D-Ribose	u	U	∅	u	U	U	∅	u	∅	∅	U	∅	∅	∅	U	∅
19	D-Sorbitol	U	U	∅	U	U	U	∅	U	U	U	U	U	U	u	U	U
20	L-Sorbose	u	U	∅	u	U	U	∅	∅	U	∅	∅	∅	∅	∅	U	∅
21	Starch, soluble	U	∅	∅	∅	∅	∅	∅	U	∅	∅	U	∅	∅	∅	∅	∅
22	Sucrose	U	U	∅	∅	U	U	U	U	U	U	∅	U	∅	U	U	U
23	Trehalose	U	U	∅	∅	U	U	u	U	u	U	U	U	∅	∅	U	∅
24	D-Xylose	U	U	∅	∅	U	U	∅	u	U	U	U	U	U	U	U	U
25	Citrate	U	U	u	U	U	u	∅	U	u	U	∅	U	∅	u	U	∅
26	Potassium D-gluconate	u	U	∅	U	U	U	u	u	U	U	u	U	U	U	U	U
27	Calcium 2-keto-D-gluconate	U	U	∅	∅	U	U	U	∅	u	∅	U	∅	∅	∅	∅	∅
28	Potassium 5-keto-D-gluconate	U	u	∅	∅	U	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅
29	α-Methyl-D-glucoside	u	U	∅	∅	U	U	∅	U	U	U	u	U	∅	∅	U	∅
30	i-Inositol	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅
31	DL-Lactate	U	u	U	U	∅	u	u	U	U	U	∅	U	U	U	u	U
32	Pyruvate	U	U	U	U	U	u	u	U	U	U	u	U	U	U	U	U
33	Potassium sodium saccharate	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅
34	Salicin	∅	U	∅	u	∅	U	∅	U	U	U	U	U	U	U	U	U
35	Succinate	U	U	U	U	U	U	∅	U	U	U	∅	U	U	U	U	U

/1/ Saccharomyces rosei.

24. UTILIZATION OF CARBOHYDRATES: YEASTS (Concluded)

Utilized (U); Not Utilized (Ø); Variable (u)

	Yeast / Carbohydrates and related substances	Hansenula subpelliculosa	Kloeckera brevis[2]	Nadsonia fulvescens	Nematospora coryli	Pichia alcoholophila[3]	Rhodotorula gracilis[4]	R. minuta	Saccharomyces bayanus	S. marxianus	Saccharomycoides ludwigii	Schizosaccharomyces octosporus	Torulaspora rosei[1]	Torulopsis bacillaris	T. utilis[5]	Trichosporon capitatum	Zygosaccharomyces fermentati[6]	Z. pastori[7]
	(A)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)	(Z)	(BB)	(CC)	(DD)	(EE)	(FF)	(GG)	(HH)	(II)
1	D-Arabinose	Ø	Ø	Ø	Ø	Ø	U	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
2	L-Arabinose	u	Ø	Ø	Ø	Ø	U	U	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
3	Cellobiose	U	U	Ø	Ø	Ø	U	U	Ø	U	U	Ø	Ø	Ø	U	Ø	U	Ø
4	Dulcitol	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
5	i-Erythritol	U	Ø	Ø	Ø	Ø	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
6	Ethyl alcohol	U	Ø	U	U	U	U	U	U[8]	U	U	u	U	Ø	U	U	u	U[8]
7	Galactose	u	Ø	Ø[9]	Ø	Ø	U	U	Ø	U	Ø	Ø	Ø	Ø	Ø	U	U	Ø
8	Glucose	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
9	Glycerol	U	Ø	U	U	U	U	U	U	U	u	Ø	U	Ø	U	U	u	U
10	Inulin	Ø	Ø	Ø	Ø	Ø	u	Ø	Ø	U	Ø	Ø	U	Ø	u	Ø	U	Ø
11	Lactose	Ø	Ø	Ø	Ø	Ø	Ø	U[8]	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
12	Maltose	U	Ø	Ø[9]	U	Ø	U	Ø	U	Ø	Ø	U	u	Ø	U	Ø	U	Ø
13	D-Mannitol	U	Ø	Ø	Ø	Ø	U	u	U	U	Ø	Ø	U	Ø	u	Ø	U	U
14	Melezitose	u	Ø	Ø	Ø	Ø	U	U	Ø	Ø	Ø	Ø	Ø	Ø	U	Ø	U	Ø
15	Melibiose	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
16	Raffinose	U	Ø	Ø	U	Ø	U	U	U	U	U	Ø	U	U	U	Ø	U	Ø
17	L-Rhamnose	Ø	Ø	Ø	Ø	Ø	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	U
18	D-Ribose	u	Ø	Ø	Ø	Ø	U	U	Ø	u	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
19	D-Sorbitol	U	Ø	u	Ø	Ø	U	u	Ø	U	Ø	Ø	U	Ø	u	Ø	U	U
20	L-Sorbose	Ø	Ø	U	Ø	U	Ø	U	Ø	Ø	Ø	Ø	U	Ø	Ø	U	U	Ø
21	Starch, soluble	u	Ø	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
22	Sucrose	U	Ø	Ø[9]	U	Ø	U	U	U	U	U	Ø	U	U	U	Ø	U	Ø
23	Trehalose	U	Ø	Ø	U	Ø	U	U	U	u	Ø	Ø	U	Ø	U	Ø	U	U
24	D-Xylose	u	Ø	Ø	Ø	u	U	U	Ø	U	Ø	Ø	Ø	Ø	U	Ø	u	Ø
25	Citrate	U	Ø	Ø	Ø	Ø	U	Ø	Ø	u	Ø	Ø	Ø	Ø	U	Ø	Ø	Ø
26	Potassium D-gluconate	U	U	U	Ø	Ø	U	U	Ø	Ø	Ø	Ø	Ø	U	U	Ø	u	Ø
27	Calcium 2-keto-D-gluconate	Ø	U	Ø	Ø	Ø	U	U	Ø	Ø	Ø	Ø	Ø	U	Ø	Ø	U	Ø
28	Potassium 5-keto-D-gluconate	Ø	Ø	Ø	Ø	Ø	Ø	U	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
29	α-Methyl-D-glucoside	U	Ø	Ø	Ø	Ø	U	U	U	Ø	Ø	Ø	Ø	u	u	Ø	U	Ø
30	i-Inositol	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
31	DL-Lactate	U	Ø	Ø	Ø	u	U	u	U	U	Ø	Ø	U	Ø	U	U	u	U
32	Pyruvate	U	Ø	Ø	Ø	u	U	U	U	U	Ø	Ø	U	Ø	U	U	u	U
33	Potassium sodium saccharate	Ø	Ø	Ø	Ø	Ø	Ø	u	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
34	Salicin	U	U	Ø	Ø	Ø	U	U	Ø	U	u	Ø	Ø	Ø	U	Ø	U	Ø
35	Succinate	U	Ø	U	U	u	U	U	Ø	U	Ø	Ø	Ø	Ø	U	U	U	U

/1/ Saccharomyces rosei. /2/ K. aspiculata. /3/ P. membranaefaciens. /4/ R. glutinis. /5/ Candida utilis. /6/ Saccharomyces fermentati. /7/ Saccharomyces pastori. /8/ Also reported not utilized. /9/ Also reported utilized.

25. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS) REQUIREMENTS: FUNGI

Data are applicable to vitamins which must be supplied each organism in its substrate. In each case, the organism synthesizes all other vitamins needed in its metabolism. O denotes that the organism synthesizes all the vitamins it requires. Certain species, not listed in this table, require growth substrates of a yet unidentified nature, which may be supplied by the addition of yeast extract or other complex organic materials. Different isolates of the same species may have different vitamin requirements.

Biotin (B); Inositol (I); Niacin (N); Pantothenic acid (Pan); Para-aminobenzoic acid (Pab); Pyridoxine (Pyx); Thiamine (T); None (O);

	Species (A)	Vitamins Required in Substrate (B)
1	Absidia ramosa	T[1]
2	Absidia spp.[2]	O
3	Acanthorhynchus vaccinii	T or B
4	Achlya conspicua	O
5	Achorion spp.[3]	O
6	Acremoniella lutzi	O
7	Acremonium potronii	T
8	Allescheria boydii	B
9	Allomyces arbusculus	T[4]
10	Alternaria solani	O
11	Amanita pantherina	T[5]
12	Apanomyces camptostylus	O
13	A. phycophilus	T
14	Armillaria mellea	O
15	Ascobolus spp.[6]	O
16	Ascochyta pisi	O
17	Ascoidea rubescens	Pyx
		T
18	Ashbya gossypii	B
		I
		T
19	Aspergillus spp.[7]	O
20	Basidiobolus ranarum	O
21	Basisporium gallarum	O
22	Blakeslea trispora	T[1]
23	Blastocladia pringsheimii	B
		N
		T
24	Blastomyces brasiliensis	T
25	B. dermatitidis	O
26	Boletus spp.[8]	T[9]
27	Bombardia lutea	O
28	Botryotinia convolute	T[10]
29	Botrytis allii and cinerea	O
30	Brettanomyces bruxellasis	Pyx
31	Bulgaria inquinans	T
32	Calocera viscosa	T
33	Candida chevalieri	O
34	C. pseudotropicalis	B
	C. pseudotropicalis (cont'd)	N
		Pan
		T
35	C. suaveolens	T
36	C. spp.[11]	B
37	C. spp.[12]	B
		T
38	Catenularia sp.	O
39	Cenococcum graniforme	B[10]
		T[1]
40	Cephalosporium recifei	O
41	Cephalothecium roseum	O
42	Ceratostomella adisposum	I
43	C. leptographioides	B[10]
44	C. rostrocylindrica	O
45	C. steroceras	T
46	Ceratostomella spp.[13,14]	B[9]
		Pyx[9]
		T
47	Ceratostomella spp.[15]	Pyx[9]
		T[10]
48	C. obscura and radicicola	B
		T
49	Cercospora apii and beticola	O
50	Chaetocladium brefeldii and macrosporum	T
51	Chaetomium convoluta	B
		T
52	Chaetomium spp.[16]	O
53	Chaetostylum fresenii	O
54	Chalara quercina[17]	B[10]
		T[10]
55	Chalaropsis thielavioides	T
56	Choanephora cucurbitarum	T
57	Ciboria acerina[17]	O
58	C. acerina[17]	T[10]
59	C. acerina[17]	B[10]
		T
60	C. pseudotuberosa	T[10]
61	Ciborinia erythronii	O
62	Circinella aspera and spinosa	O
63	Cladosporium herbarum and wernecki	O
64	Clavaria ligula	T
65	Clitocybe spp.[18]	T
66	Clitopilus prunulus	T[5]
67	Coemansia interrupta	B
		T
68	Colletotrichum circinans	O
69	C. lindemuthianum[17]	O
70	C. lindemuthianum[17]	T[10]
71	Collybia spp.[19]	T
72	C. dryophila	B
		T
73	C. velutipes	B[20]
		T[21]
74	Coprinus spp.[7]	T[22]
75	Cordyceps militaris	O
76	Corticium vagum	T
77	Cortinellus bulbiger	T
78	Coryne sarcordia	B
		T
79	Cryptococcus sp.	T
80	Cudonia circinans	T
81	Cunninghamella spp.[23]	O
82	Cyathus striatus	T
83	Cytospora sp.	T
84	Dacryomyces stillatus	T
85	Daedalea spp.[24]	T
86	Daldinia concentrica	O
87	Dasyobolus immersus	T
88	Debaryomyces membranefaciens	B
		T
89	Debaryomyces spp.[25]	B
90	Deconica inquilina	T
91	Dematium chodati and pullulans	O
92	D. nigrum	T
93	Dendrophoma obscurans	T
94	Dermatea balsamea	T
95	Diaporthe strumella	O
96	Dichranophora fulva	T
97	Diplodia macrospora	B
98	Dipodascus uninucleatus	B
		T
99	Dothidella quercus	O
100	Endodermophyton concentricum and tropicale	O
101	Endothia parasitica	B
		T
102	Entyloma arnoseridis	O
103	Epichloe typhina	I[10]
		T
104	Epidermophyton floccosum	O
105	Eremascus fertilis	O
106	Eremothecium ashbyi	B
		I
		T
107	Exobasidium vaccinii	T
108	Flammula carbonaria and penetrans	T
109	Fomes spp.[26]	T
110	F. fraxineus	O
111	Fusarium avenaceum[27]	B
112	Fusarium spp.[28]	O
113	Ganoderma lucidum	T
114	Glenosporella loboi	O
115	Glenosporopsis amazonica	T
116	Gliocladium fimbriatum	O
117	Gloeocystidium roseocremum	T
118	Glomerella cingulata	O
119	Grossmannia serpens	B
120	Gymnoascus setosus	O
121	Hansenula anomala	O
122	H. subpelliculosa	T
123	H. suaveolens	B
124	Haplosporangium parvum	O

25. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS) REQUIREMENTS: FUNGI (Continued)

125	Helminthosporium spp.[29]	O
126	Helvella infula	T
127	Hemispora stellata	O
128	Histoplasma capsulatum	O
129	H. capsulatum[27]	B
130	Hormiscium dermatitidis	T
131	Hormodendrum algeriensis and pedroi	T
132	H. langeroni	O
133	Hydnum spp.[30]	T
134	H. coralloides	O
135	Hypholoma spp.[31]	T
136	Hypochnus solani	O
137	Hypoxylon pruinatum	B
		T
138	Indiella americana	T
139	Isoachlya monilifera	O
140	Kloeckera brevis	B
		I
		N
		Pan
		Pyx
		T
141	Lachnum pygmaeum	B
		T
142	Lactarius deliciosus	T
143	Lambertella corni-maris	B^{10}
		T
144	Lambertella spp.[32]	B^{10}
		T
145	Lentinus omphalodes	T
146	L. tigrinus	T[33]
147	Lenzites spp.[34]	T^{10}
148	L. sepiaria	T[20,35]
149	Lepiota amianthina and procera	T
150	Lophodermium pinastri	B
		I^{10}
		T
151	Madurella americana	O
152	Malessezia furfur	T
153	Marasmius androsaceus	B^{10}
		T^{5}
154	M. perforans	B
		T
155	Marasmius spp.[36]	T[9,22]
156	Martinia panamaensis	T^{10}
157	Melanconium betulinum	B
		I
		T
158	Melanospora destruens	B
		T
159	Memnoniella echinata	B
160	Merulius lachrymans	T
161	Microsporum audouini	N
		Pyx
162	Microsporum spp.[37]	O
163	Monascus purpureus	O
164	Monilia albicans and metalondinenus	B
165	Monilinia fructicola	O[38]
166	M. laxa	T
167	Monosporium apiospermum	O
168	Mortierella spp.[7]	O
169	Mucor mucedo	T
170	M. ramannianus	T[39]
171	Mucor, spp.[40]	O
172	Mycena rubromarginata	O
173	M. sanguinolenta	O
174	M. spp.[41]	T^{42}
175	Mycelium radicis atrovirens	O
176	Mycoderma lipolytica	T
177	M. valida	B
178	Mycotorula lactis	N
179	Mycosphaerella confusa and grossulariae	O
180	M. sentina	T
181	Nectria coccinea	T^{10}
182	Nematospora coryli	O
183	N. gossypii	B
		I
		T
184	Neocosmospora vasinfecta	O
185	Neurospora spp.[43]	B
186	Nyctalis asterophora	T^{1}
187	Omphalia gracillima	T
188	Ophiobolus graminis	B
		T
189	O. miyabeanus	O
190	O. oryzinus	B
191	Ophiostoma catonianum	B
		Pyx
		T
192	O. coeruleum	T
193	O. fagi	B^{10}
		Pyx
194	Panaeolus campanulatus	T^{10}
195	Panus stipticus and torulosus	T
196	Paracoccidioides brasiliensis	T
197	Parasitella simplex	T
198	Penicillium digitatum[17]	B^{10}
		Pan^{10}
		Pyx^{10}
		T

/1/ Requires only pyrimidine portion of thiamine molecule. /2/ Species include: A. coerules, A. glauca, A. orchidis, A. repens, A. spinosa. /3/ Species include: A. gallinae, A. gypseum, A. schoenleinii. /4/ Plus an unknown "cofactor" which is not niacin or biotin. /5/ Can be replaced by pyrimidine and thiazole, but not by pyrimidine or thiazole. /6/ Species include: A. denudatus, A. furfuraceus, A. leveillei. /7/ In all species tested. /8/ Species include: B. elegans, B. granulatus, B. luteus, B. piperatus, B. variegatus, B. viscidus. /9/ Some species are only partially deficient, i.e., some synthesis of the vitamin presumably takes place. /10/ Partial requirement; some synthesis of the vitamin presumably takes place. /11/ Species include: C. chalmersi, C. deformans, C. flareri, C. guillermondia, C. intermedia, C. mycotoruloidea, C. parakrusei, C. stillaltides, C. zeylanoides. /12/ Species include: C. albicans, C. aldoli, C. brumpti, C. krusei, C. suaveolens, C. triadis, C. tropicalis. /13/ Species include C. fimbriata. Two isolates of this species have been reported to require thiamine only. /14/ Species also include: C. ips, C. microspora, C. montium, C. penicillata, C. piceaperda, C. pini. /15/ Species include: C. multiannulata, C. pilifera, C. pluriannulata, C. pseudotsugae, C. ulmi. /16/ Species include: C. bostrychodes, C. cochlioides, C. elatum, C. globosum. /17/ Certain isolates. /18/ Species include: C. alexandri, C. aurantiaca, C. clavipes, C. cyathiformis, C. geotropa, C. infundibuliformis, C. nebularis, C. odora, C. pithyophila. /19/ Species include: C. ambusta, C. butyracea, C. tuberosa, cf. Fn 1. /20/ The vitamin is probably only partially required. /21/ Can be replaced by pyrimidine or thiazole. /22/ Some species require pyrimidine and thiazole, others pyrimidine only. /23/ Species include: C. bertholletiae, C. echinulata, C. elegans. /24/ Species include: D. confragosa; D. quercina, D. unicolor, cf. Fn 20. /25/ Species include: D. fabrii, D. guillermondi, D. hudeloi, D. matruchoti subglobosus. /26/ Species include: F. annosus, F. igniarius, F. pinicola. /27/ One strain only. /28/ In most species tested. /29/ Species include: H. gramineum, H. sativum, H. victoriae. /30/ Species include: H. auriscalpium, H. corrugatum, H. erinaceus. /31/ Species include: H. capnoides; H. fasciculare, cf. Fn 5 and 20; H. sublateritium. /32/ Species include: L. hicoriae, L. pruni, L. viburni. /33/ Pyrimidine plus thiazole are equally as effective as thiamine; pyrimidine alone is less effective. /34/ Species include: L. abietina, cf. Fn 10; L. betulina, L. trabea, cf. Fn 10. /35/ Might be replaced by pyrimidine. /36/ Species include: M. alliaceus, M. chordalis, M. epiphyllus, M. foetidus, M. fulvo-bulbillosus, M. graminum, M. perniciosus, M. peronatus, M. putillus, M. ramealis, M. rotula, M. scorodonius. /37/ Species include: M. canis, M. ferrugineum, M. fulvum. /38/ Some isolates show partial thiamine deficiency. /39/ Requires only thiazole portion of thiamine molecule. /40/ Species include: M. circinelloides, M. genevensis, M. griseolilacinus, M. hiemalis, M. mucilagineus, M. stolonifer, M. tenuis. /41/ Species include: M. alcalina, M. amicta, M. cinerella, M. debilis, M. epipterygia, M. flavo-alba, M. galericulata, M. galopoda, M. lactea, M. metata, M. polygramma, M. rosella, M. viscosa, M. vulgaris, M. zephyra. /42/ In many species probably additional (partial) requirements. /43/ Species include: N. crassa, N. sitophila, N. tetrasperma.

25. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS) REQUIREMENTS: FUNGI (Continued)

Data are applicable to vitamins which must be supplied each organism in its substrate. In each case, the organism synthesizes all other vitamins needed in its metabolism. 0 denotes that the organism synthesizes all the vitamins it requires. Certain species, not listed in this table, require growth substrates of a yet unidentified nature, which may be supplied by the addition of yeast extract or other complex organic materials. Different isolates of the same species may have different vitamin requirements.

Biotin (B); Inositol (I); Niacin (N); Pantothenic acid (Pan); Para-aminobenzoic acid (Pab); Pyridoxine (Pyx); Thiamine (T); None (0)

	Species (A)	Vitamins Required in Substrate (B)
199	Penicillium spp.[44]	0
200	Peniophora spp.[45]	T
201	Phacidium infestans	T^{10}
202	Phialophora spp.[46]	T
203	Pholiota adiposa	B^{10}
		Pyx^{10}
		T^{10}
204	P. mutabilis and squarrosa	T
205	Phoma apiicola and betae	0
206	Phycomyces blakesleeanus	T^{47}
207	P. nitens	T
208	Phymatotrichum omnivorum	0
209	Phytophthora spp.[7]	T^{48}
210	Pichia alcoholophila	B
211	P. belgica	B
		I
		Pyx
		T
212	P. dombrowski	T
213	P. kluyveri	B
		T
214	Piedraia hortai	T
215	Pilaira anomala and moreaui	T
216	Piptocephalis freseniana	0
217	Piricularia oryzae	B
		T
218	Pityrosporum ovale	B
		T
219	Pleurage curvicolla	B
		T
220	Pleurotus corticatus	T
221	Podospora curvula	B
		T
222	Polyporus spraguei	0
223	Polyporus spp.[49]	T^{50}
224	Polystictus versicolor	Pyx^{10},T^{51}
225	Psalliota bispora	B or T
226	P. campestris	0
227	Pseudopeziza ribis	B
228	Pyronema confluens	T
229	P. domesticum	0
230	Pythiomorpha gonapodyoides	T^{1}
231	P. oryzae	T^{51}
232	Pythium spp.[52]	0
233	P. spp.[53]	T^{22}
234	Rhizopogon roseolus	B^{10}
		T
235	Rhizopus spp.[7]	0
236	Rhodotorula aurantica	Pab
		T^{51}
237	R. aurea and glutinis	0
238	Rhodotorula spp.[54]	T
239	Rosellinia arcuata	B
240	R. necatrix and thelena	0
241	Sabouraudites gypseus and radiolatus	0
242	Saccharomyces carlsbergensis	B
		Pan
243	S. carlsbergensis mandshuricus	B
		Pan
		Pyx
244	S. cerevisiae ellipsoideus	B
		I
		Pan
		T
245	S. chodati	B
		Pan
		Pyx
246	S. fragilis	B
		Pan
		Pyx
		T
247	S. globosus	B
		N
		T
248	S. logos	Pan
		T
249	S. ludwigii	B
		I
	S. ludwigii (cont'd)	N
		Pan
		Pyx
		T
250	S. macedoniensis	B
		N
		Pan
		T
251	S. oviformis	B
		Pan
		Pyx
252	S. tubiformis	B
		Pan
253	S. uvarum	B
		I
		Pan
254	Saccobolus depauperatus	B
255	Saprolegnia delica	0
256	S. mixta	0
257	Schizophyllum commune	T
258	Schizosaccharomyces pombe	B
		I
		N
		Pan
259	Schwannomyces occidentalis	B
260	Sclerotinia camelliae	B
		I^{10}
		T
261	S. minor	B^{10}
		T^{20}
262	S. sclerotiorum	0
263	Sclerotium delphinii	T^{1}
264	S. rolfsii	T^{39}
265	Septoria apii	T^{1}
266	Septoria spp.[55]	0
267	Sistotrema confluens	T
268	Sordaria fimicola[56]	B
269	S. fimicola[17]	B
		T
270	Spathularia flavida	B
		Pyx
270	S. flavida (cont'd)	T
271	Spermophthora gossypii	0
272	Sphaerobolus stellatus	0
273	Sphaeropsis malorum	0
274	Sphaerulina trifolii	T
275	Sporormia intermedia	B
276	Sporotrichum schenckii	T
277	Sporotrichum spp.[57]	0
278	Stachybotrys atra	B
279	Stereum frustulosum	T^{39}
280	S. murrayi	0
281	Stromatinia smilacinae	T^{10}
282	Stropharia semiglobata	T
283	Syncephalastrum cinereum	0
284	Thamnidium elegans	0
285	Thielaviopsis basicola	T^{51}
286	Thraustotheca clavata[17]	B
287	Tilletia horrida	T^{5}
288	T. levis	0
289	T. tritici	T^{58}
290	Torula cremoris	B
		N
		T
291	T. hansen	0
292	T. lactis	N
293	T. sphaerica	B
		N
294	T. fermentati and laurentii	T^{51}
295	T. rosea and sanguinea	T
296	T. kefyr and molischiana	B
297	Torulaspora delbruckii and fermentati	B
298	Torulopsis candida	B
299	T. dattila	B
		Pyx
		T
300	T. kefyr	N
301	T. laurentii and neoformans	T

25. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS) REQUIREMENTS: FUNGI (Concluded)

302	Torulopsis spp.[59]	B
303	Trachysphaera fructigena	B
304	Trametes spp.[60]	T
305	Trichoderma lignorum	0
306	Tricholoma spp.[61]	T[9,22]
307	Trichophyton discoides	B
		I
		Pyx
		T
308	T. flaviforme	I
		T
309	T. mentagrophytes[17]	0
310	T. mentagrophytes[27]	I
		T
311	Trichophyton, spp.[62]	0
312	T. sulfureum	0
	and violaceum	T
313	Trichophyton spp.[63]	T
314	Trichosporon beigelii	B
		T
315	T. minor	T
316	Tubaria furfuracea	T
317	Typhula variabilis	T
318	Ustilago, longissima	T[1,10]
319	Ustilago spp.[64]	T[5]
320	Ustilago spp.[65]	0
321	Ustilina vulgaris	0
322	Valsa ceratophora	T[10]
323	V. pini	B
		I
323	V. pini (cont'd)	T
324	Venturia inaequalis	0
325	Xylaria arbuscula	0
326	X. polymorpha	0
327	X. hypoxylon	T
328	Zygorhynchus spp.[66]	0
329	Zygosaccharomyces barkeri	B
		Pan
		T
330	Z. bisporus	B
		T
331	Z. japonicus	B
		I
		Pan
331	Z. japonicus (cont'd)	T
332	Z. lactis	B
		N
333	Z. mandshuricus	B
		T
334	Z. marxianus	B
		N
335	Z. nadsonii	B
		Pan
336	Z. pastori	B
		Pan
337	Z. pini	B
338	Z. priorianus	B
		I
		Pan

/1/ Requires only pyrimidine portion of thiamine molecule. /5/ Can be replaced by pyrimidine and thiazole, but not by pyrimidine or thiazole. /7/ All species tested. /9/ Some species are only partially deficient, i.e., some synthesis of the vitamin presumably takes place. /10/ Partial requirement; some synthesis of the vitamin presumably takes place. /17/ Certain isolates. /20/ The vitamin is probably only partially required. /22/ Some species require pyrimidine and thiazole, others pyrimidine only. /27/ One strain only. /39/ Requires only thiazole portion of thiamine molecule./44/ In all other species tested./45/ Species include: P. candida, P. cinctula, P. fraxinea, P. junipericola, P. septentrionalis, P. violaceo-livida. /46/ Species include: P. compactum, P. jeanselmei, P. pedrosoi, P. verrucosa. /47/ Requires intact thiamine molecule or pyridoxine plusthiazole. /48/ Most species require intact thiamine molecule; P. fagopyri needs only pyrimidine. /49/ Species include: P. abietinus, P. adustus, P. anceps, P. annosus, P. benzoinus, P. cervinus, P. fomentarius, P. nidulans, P. squamosus, P. zonatus. /50/ P. adustus requires only pyrimidine; most other species can grow with pyrimidine plus thiazole but P. benzoinus and P. zonatus require intact thiamine molecule. /51/ Requires intact thiamine molecule. /52/ Species include: P. debaryanum, P. deliense, P. graminicolum, P. hyphalosticton, P. intermedium, P. irregulare, P. mamillatum, P. scleroteichum, P. splendens. /53/ Species include: P. arrhenomanes, P. ascophallon, cf. Fn 50; P. butleri, P. oligandrum, P. polycladon, P. polymostum, cf. Fn 50. /54/ Species include: R. flava, R. mucilaginosa, R. rubra, R. sanniei. /55/ Species include: S. azaleae, S. callistephi, S. chrysanthemella, S. nodorum. /56/ Most isolates. /57/ Species include: S. beurmanni, S. councilmanni, S. gougeroto. /58/ There are conflicting reports in this species on the replaceability of thiamine by pyrimidine plus thiazole or by pyrimidine alone. /59/ Species include: T. molischiana, T. minor, T. pulcherrima. /60/ Species include: T. cinnabarina, T. heteromorpha, T. serialis. /61/ Species include: T. albobrunneum, T. brevipes, T. flavobrunneum, T. fumosum, T. gambosum, T. imbricatum, T. nudum, T. personatum, T. pessundatum, T. vaccinum. /62/ Species include: T. rubrum, T. sabouraudi, T. tonsurans. /63/ Species include: T. acuminaturm, T. interdigitale, T. rosaceum. /64/ Species include: U. pinguieulae, U. scabiosae, U. vinosa, U. violacea; also 7 species closely related to U. violacea. /65/ Species include: U. avenae, U. bromivora, U. hordei, U. levis, U. nuda, U. striiformis, U. tritici, U. zeae. /66/ Species include: Z. daneardi, Z. exponens, Z. heterogamus, Z. moelleri.

26. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS: BACTERIA

Required (R); Not required (✗)

	Organism / Vitamins and Related Substances	Aerobacter aerogenes	Bacillus alvei	B. anthracis	B. brevis	B. cereus	B. cereus var. mycoides	B. circulans	B. coagulans	B. licheniformis	B. macerans	B. megaterium	B. pasteurii	B. polymyxa	B. pumilis	B. sphaericus	B. subtilis	B. subtilis var. niger	Brucella abortus	B. melitensis	B. suis	Erwinia[1]	E. amylovora	E. tracheiphila	Escherichia coli	Hemophilus influenzae
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)	(Z)
1	Vitamin A	✗																	✗	✗	✗	✗	✗	✗	✗	✗
2	Ascorbic acid	✗																	✗	✗	✗	✗	✗	✗	✗	✗
3	Biotin	✗	✗	✗	✗	✗	✗	R	R	✗	R	✗	R?	R	R	R?	✗	✗	R	R	R	✗	✗	✗	✗	✗
4	Choline	✗																	✗	✗	✗	✗	✗	✗	✗	✗
5	Cobalamin[2]	✗																	✗	✗	✗	✗	✗	✗	✗	✗
6	Vitamin D	✗																	✗	✗	✗	✗	✗	✗	✗	✗
7	Vitamin E	✗																	✗	✗	✗	✗	✗	✗	✗	✗
8	Folic acid group[3]	✗																	✗	✗	✗	✗	✗	✗	✗	✗
9	Inositol	✗																	✗	✗	✗	✗	✗	✗	✗	✗
10	Vitamin K	✗																	✗	✗	✗	✗	✗	✗	✗	✗
11	Niacin[4]	✗	✗	✗	✗	✗	✗	✗	R[5]	✗	✗	✗	R?	✗	✗	✗	✗	✗	R	R	R	✗	R	R[1]	✗	✗
12	Pantothenic acid	✗																	R	R	R	✗	✗	✗	✗	✗
13	Para-aminobenzoic acid	✗																	✗	✗	✗	✗	✗	✗	✗	✗
14	Pyridoxine group[6]	✗																	✗	✗	✗	✗	✗	✗	✗	✗
15	Riboflavine	✗																	✗	✗	✗	✗	✗	✗	✗	✗
16	Thiamine	✗	R	R	✗	✗	✗	R	R	✗	R	✗	R	✗	✗	R	✗	✗	R	R	R	✗	✗	✗	✗	✗
17	Other substances	✗																	✗	✗	✗	✗	✗	✗	✗	R[7]

/1/ Various strains. /2/ A generic term including cyancobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /3/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /4/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /5/ One strain only. /6/ Includes pyridoxine, pyridoxal, pyridoxamine. /7/ Hemin, diphosphopyridine.

26. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS: BACTERIA (Concluded)

Required (R); Not required (✗)

Vitamins and Related Substances / Organism	Hemophilus para-influenzae	Lactobacillus (hetero-fermentative)	L. (homo-fermentative)	Leuconostoc citrovorum	L. dextranicum	L. mesenteroides	Pasteurella multocida	P. pestis	P. pseudotuberculosis	P. tularense	Proteus morgani	P. vulgaris	P. X 19	Salmonella cholerae-suis	S. enteritidis	S. gallinarum	S. pullorum	S. schottmuelleri	S. typhosa	Serratia marcescens	Shigella alkalescens	S. paradysenteriae	S. sonnei	Staphylococcus albus	S. aureus
(A)	(BB)	(CC)	(DD)	(EE)	(FF)	(GG)	(HH)	(II)	(JJ)	(KK)	(LL)	(MM)	(NN)	(OO)	(PP)	(QQ)	(RR)	(SS)	(TT)	(UU)	(VV)	(WW)	(XX)	(YY)	(ZZ)
1 Vitamin A									✗					✗	✗		✗	✗	✗	✗	✗				
2 Ascorbic acid									✗					✗	✗		✗	✗	✗	✗	✗				
3 Biotin		R	R	R	R	R	R^{1}		✗					✗	✗		✗	✗	✗	✗	✗			R^{8}	R^{8}
4 Choline									✗					✗	✗		✗	✗	✗	✗	✗				
5 Cobalamin[2]		$R^{1,9}$	$R^{1,9}$						✗					✗	✗		✗	✗	✗	✗	✗				
6 Vitamin D									✗					✗	✗		✗	✗	✗	✗	✗				
7 Vitamin E									✗					✗	✗		✗	✗	✗	✗	✗				
8 Folic acid group[3]		$R^{1,10}$	$R^{1,10}$	R	R	R			✗					✗	✗		✗	✗	✗	✗	✗				
9 Inositol									✗					✗	✗		✗	✗	✗	✗	✗				
10 Vitamin K									✗					✗	✗		✗	✗	✗	✗	✗				
11 Niacin[4]		R	R	R^{11}	R^{11}	R^{11}	R^{12}		✗		R	R	R^{13}	✗	✗		R^{1}	✗	✗	✗	✗	R^{14}	R^{14}	R	R
12 Pantothenic acid		R	R	R	R	R	R		✗		R			✗	✗		✗	✗	✗	✗	✗	R^{1}	R^{1}	$R^{8,15}$	$R^{8,15}$
13 Para-aminobenzoic acid		$R^{1,10}$	$R^{1,10}$						✗					✗	✗		✗	✗	✗	✗	✗				
14 Pyridoxine group[6]		$R^{1,10}$	$R^{1,10}$	$R^{10,15}$	$R^{10,15}$	$R^{10,15}$			✗					✗	✗		✗	✗	✗	✗	✗			$R^{8,15}$	$R^{8,15}$
15 Riboflavine		✗	R	$R^{10,15}$	$R^{10,15}$	$R^{10,15}$			✗					✗	✗		✗	✗	✗	✗	✗				
16 Thiamine		R	R	$R^{10,15}$	$R^{10,15}$	$R^{10,15}$			✗	R^{16}				✗	✗	R	✗	✗	✗	✗	✗			R	R
17 Other substances	R^{17}	R^{18}	R^{18}	R^{19}	✗	✗		R^{20}	✗	R^{21}				✗	✗		✗	✗	✗	✗	✗				

/1/ Various strains. /2/ A generic term including cyancobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /3/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /4/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /6/ Includes pyridoxine, pyridoxal, pyridoxamine. /8/ Coagulase (-) strains. /9/ Or nucleotides. /10/ Occasional requirement as growth stimulant. /11/ Nicotinic acid for some strains only. /12/ Nicotinamide. /13/ Occasional strains have no known requirement. /14/ Usually. /15/ Occasionally. /16/ Thiamine diphosphate. /17/ Diphosphopyridine nucleotide; putrescine. /18/ Some strains require pyridoxal phosphate and pantethine. /19/ Citrovorum factor stimulates growth of strain 8081. /20/ Aerobic require hemin; anaerobic have no known requirements. /21/ Adenosine among others.

27. DAILY NUTRIENT ALLOWANCES: MAN, ADULT, CANADA

In the absence of actually measured means and ranges the table presents estimates of the mean Calories of energy expenditure and mean intakes of various nutrients needed to satisfy the physiological requirements of healthy 70 kg men and 56 kg women residing in Canada and obtaining the required nutrients from ordinary dietary sources. Available data do not permit an estimate of the ordinary ranges of variation. For persons whose body weights differ from 70 kg and 56 kg, recalculate each value (cf. footnotes). Blank spaces indicate lack of data, not absence of requirement. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison between species and does not necessarily imply a close correlation between nutrient need and body weight (but cf. Fn 10). Requirements per kilogram body weight which appear to be affected by sex arise from the fact that maintenance requirement is related to weight but independent of sex, while work allowances are independent of weight and may differ with sex at different intensities of activity.

	Specifications / Nutrients per kg body weight per day	Required (R)								
		♂70 kg	♀56 kg	♂70 kg	♀56 kg	♂70 kg	♀56 kg	♂70 kg	♀65 kg	♀56 kg
		Sedentary		Moderate Activity		Heavy Activity		Very Heavy Activity	Pregnancy[1]	Lactation[2]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
1	Water[3,4], ml	35	38	43	43	54	52	68	40	56
2	Calories, metabolizable[5,6]	35	38	43	43	54	52	68	40	56
3	Total food (dry)[3,7], g	7.6	8.2	9.2	9.3	10.8	10.5	13.7	8.6	11.9[8]
4	Residue									
5	Protein[9,10], g	0.96	1.0	0.96	1.0	0.96	1.0	0.96	1.3	1.5
6	Carbohydrate[3,11], g	5.7	6.1	7.1	7.1	7.7	7.4	7.2	6.3	9.0[8]
7	Fat[3,12], g	1.0	1.1	1.2	1.2	2.1	2.0	2.6	1.1	1.6[8]
8	"Essential" fatty acids									
9	Vitamin A as β-carotene[10,13], µg	43	43	43	43	43	43	43	55	66
10	Ascorbic acid[14,15], mg	0.43	0.54	0.43	0.54	0.43	0.54	0.43	0.46	0.54
11	Biotin									
12	Choline									
13	Cobalamin[16]									
14	Vitamin D, calc. as calciferol[14,17], µg								0.16	0.18
15	Vitamin E[18]									
16	Folic acid group[19]									
17	Inositol									
18	Vitamin K[20]									
19	Niacin[3,21], mg	0.11	0.12	0.13	0.14	0.16	0.16	0.21	0.13	0.17
20	Pantothenic acid									
21	Para-aminobenzoic acid									
22	Pyridoxine group[22]									
23	Riboflavine[3,23], µg	17	18	21	20	25	25	32	20	27
24	Thiamine[3,24], µg	11	12	13	14	16	16	21	14	17

25	Calcium[10], mg	10	10	10	10	10	10	10	25	28
26	Chlorine[14,25], mg	43	54	43	54	43	54	43	46	54
27	Cobalt									
28	Copper	R	R	R	R	R	R	R	R	R
29	Fluorine									
30	Iodine[10,26], µg	4	4	4	4	4	4	4	4	4
31	Iron[14,27], mg	0.086	0.214	0.086	0.214	0.086	0.214	0.086	0.231	0.268
32	Magnesium									
33	Manganese									
34	Molybdenum									
35	Phosphorus[10,28], mg	10	10	10	10	10	10	10	25	28
36	Potassium									
37	Silicon									
38	Sodium[14,25], mg	28	36	28	36	28	36	28	31	36
39	Sulfur									
40	Zinc									

/1/ Values are for "sedentary activity" plus added allowances for last half of pregnancy. /2/ "Sedentary activity" plus added allowance. /3/ Calorie-correlated. /4/ Breaks calorie-correlation of 1 ml per kilocalorie of food in excessively hot environment. /5/ For adult man or woman, maintenance Cal. (= weight-correlated, cf. Fn 10) = 1.33 x basal metabolism = $93(W^{0.75})$, where W is body weight in kilograms. To maintenance Calories add per person: for sedentary work, ♂225, ♀225; moderate work, ♂750, ♀500; heavy work, ♂1500, ♀1000; very heavy work, ♂2500; pregnancy, latter half, 500; lactation, 1000. /6/ Kilocalories, net utilizable for heat and total activity. The coefficients 4.0, 4.0 and 9.0 have been used for calculating the kilocalorie value of ingested grams of protein, carbohydrate and fat (5A,6A,7A). /7/ Sum of 5A,6A,7A, each carried to two decimal places. Rounding off of these, as presented, introduces apparent discrepancy between them and their sum. /8/ If fat taken as 35% of Calories 3J = 11.3, 6J = 7.6, 7J = 2.2. /9/ Allow protein (grams) = $2.75(W^{0.75})$, where W is body weight in kilograms. /10/ Correlated with body weight. /11/ Calculated by: 2A minus Calorie value of 5A and 7A, the remainder divided by 4.0 (cf. Fn 6). /12/ Calculated by: 25% of 2A divided by 9.0 (cf Fn 6) except col. FGH where assumed 35%. /13/ Allow 18 I. U. of preformed A (0.3 µg A alcohol = one I. U.) or 72 I. U. of β-carotene (0.6 µg = one I. U.) per kg body weight. /14/ Neither weight- nor calorie-correlated? Allowance for ♂70kg or ♀56kg applies to adults of other body weights. /15/ Allow 30 mg/person. /16/ Generic term including cyanocobalamin (B_{12}) and its hydrogenation product (B_{12a}, B_{12b}) which has approximately the same biological activity. /17/ 0.025 µg calciferol = one I. U. Little or no dietary intake needed by adults except elderly people and those who are prevented from exposure to direct sunlight. /18/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /19/ "Folic acid" a generic term for pteroylglutamic acid (PGA, folacin) and pteroylglutamates. Also known as vitamin M, B_c; L. casei factor, Norite eluate factor. /20/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione; 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /21/ Generic term for nicotinic acid (niacin), nicotinic acid amide (nicotinamide), pellagra preventive (P.P.) factor. Allow 3 µg/Calorie (cf 2A). /22/ Includes pyridoxine, pyridoxal and pyridoxamine. /23/ Allow 0.5 µg/Calorie (cf 2A). /24/ Allow 0.3 µg/Calorie (cf 2A). /25/ Allow 5g NaCl/person. /26/ Allow up to 4 µg/kg. /27/ Allow ♂6, ♀12mg/person, 15 in pregnancy and lactation. /28/ Same values as those for calcium.

28. DAILY NUTRIENT ALLOWANCES: MAN, CHILDHOOD, CANADA

In the absence of actually measured means and ranges the table presents estimates of the mean Calories of energy expenditure and mean intakes of various nutrients needed to satisfy the physiological requirements of healthy juveniles of average activity residing in Canada and obtaining all required nutrients from ordinary dietary sources. Available data do not permit an estimate of the ordinary range of variation. To calculate allowances per person, multiply values in appropriate column by kg of actual body weight. Blank spaces indicate lack of data, not absence of requirement. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species and does not necessarily imply a close correlation between nutrient need and body weight. Requirements per kilogram body weight which appear to be affected by sex arise from the fact that maintenance requirement is related to weight but independent of sex, while work allowances are independent of weight and may differ with sex at different intensities of activity.

	Specifications / Nutrients per kg body weight per day	Required (R)								
		1-3 yr	4-6 yr	7-9 yr	10-12 yr		13-15 yr		16-20 yr[1]	
		♂♀12 kg	♂♀19 kg	♂♀26 kg	♂34 kg	♀37 kg	♂49 kg	♀49 kg	♂60 kg	♀53 kg
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
1	Water[2,3], ml	104	86	78	69	68	60	51	58	45
2	Calories, metabolizable[4,5,6]	104	86	78	69	68	60	51	58	45
3	Total food (dry)[2,7], g	22.4	18.5	16.8	15.3	14.6	13.0	10.9	11.8	9.8
4	Residue									
5	Protein[4,8], g	3.1	2.0	1.9	1.8	1.7	1.5	1.5	1.0	1.0
6	Carbohydrate[2,9], g	16.4	14.1	12.7	11.5	11.0	9.8	8.0	8.5	7.5
7	Fat[2,10], g	2.9	2.4	2.2	2.0	1.9	1.7	1.4	2.3	1.3
8	"Essential" fatty acids									
9	Vitamin A as β-carotene[4,11], µg	43.2	43.2	43.2	43.2	43.2	43.2	43.2	43.2	43.2
10	Ascorbic acid[12,13], mg	2.5	1.6	1.15	0.88	0.81	0.61	0.61	0.50	0.57
11	Biotin									
12	Choline									
13	Cobalamin[14]									
14	Vitamin D, calc. as calciferol[12,15], µg	0.82-1.65	0.52	0.38	0.29	0.27	0.20	0.20		
15	Vitamin E[16]									
16	Folic acid group[17]									
17	Inositol									
18	Vitamin K[18]									
19	Niacin[2,19], mg	0.31	0.26	0.23	0.21	0.20	0.18	0.15	0.17	0.14
20	Pantothenic acid									
21	Para-aminobenzoic acid									
22	Pyridoxine group[20]									
23	Riboflavine[2,21], µg	52	43	39	35	34	30	25	29	22
24	Thiamine[2,22], µg	31	25	23	21	20	18	15	17	14

25	Calcium[23], mg	83	53	38	29	29	31	31	25	28
26	Chlorine[24]	R	R	R	R	R	R	R	R	R
27	Cobalt									
28	Copper	R	R	R	R	R	R	R	R	R
29	Fluorine									
30	Iodine, µg	4	4	4	4	4	4	4	4	4
31	Iron[25], mg	0.5	0.32	0.23	0.18	0.17	0.24	0.24	0.20	0.23
32	Magnesium									
33	Manganese									
34	Molybdenum									
35	Phosphorus[23], mg	83	53	38	29	29	31	31	25	28
36	Potassium									
37	Silicon									
38	Sodium[24]	R	R	R	R	R	R	R	R	R
39	Sulfur									
40	Zinc									

/1/ Based on values calculated for adults ♂60kg, ♀53kg assumed to be doing ♂heavy or ♀moderate to heavy work. /2/ Calorie-correlated. /3/ Allow 1 ml/Calorie. /4/ Correlated with body weight. /5/ Kilocalories, net utilizable for heat, total activity and growth = 4.0P + 4.0C + 9.0F, where PCF represent grams of protein, carbohydrate and fat ingested (5A,6A,7A). /6/ Values for 2IJ based on maintenance Calories ♂2000, ♀1800 plus allowance of ♂1500, ♀600 for average activity (cf. Fn 1, this table, and Fn 5, preceding table for adults, Canada). /7/ Sum of 5A,6A,7A. /8/ Based on survey data in which normal growth was the criterion of adequacy. /9/ Calculated by: 2A minus Calorie value of 5A and 7A, the remainder divided by 4.0 (cf. Fn 3). /10/ Calculated by: 25% of 2A divided by 9.0 (cf. Fn 3), except in col. I where assumed 35%. /11/ Allow 18 I. U. of preformed A (0.3 µg A alcohol = one I. U.) or 72 I. U. of β-carotene (0.6 µg = one I. U.) per kg body weight. /12/ Neither weight- nor calorie-correlated? /13/ Allow 30 mg/person. /14/ Generic term for cyanocobalamin (B_{12}) and its hydrogenation product (B_{12a}, B_{12b}) which has approximately the same biological activity. /15/ Allow 400-800 I. U./person up to age 3 yrs., 400 I. U. thereafter to age 16 (0.025 µg calciferol = one I. U.). /16/ Generic term for alpha-, beta-, delta-, and gamma-tocopherols. /17/ "Folic acid," generic term for pteroylglutamic acid (PGA; folacin) and pteroylglutamates. Also known as vitamin M, B_c; L. casei factor, Norite eluate factor. /18/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione; 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /19/ Generic term for nicotinic acid (niacin), nicotinic acid amide (nicotinamide), pellagra preventive (P.P.) factor. Allow 3.0 µg/Calorie. /20/ Includes pyridoxine, pyridoxal and pyridoxamine. /21/ Allow 0.5 µg/Calorie. /22/ Allow 0.3 µg/Calorie. /23/ Allow 1g/person up to age 13; 1.5g up to age 16. /24/ Allow 5g NaCl/person for adults. /25/ Allow 6 mg/person up to age 13; 12 mg thereafter.

29. DAILY NUTRIENT ALLOWANCES: MAN, ADULT, UNITED KINGDOM

In the absence of actually measured means and ranges the table presents estimates of the mean Calories of energy expenditure and mean intakes of various nutrients deemed sufficient to establish and maintain a good nutritional state in healthy persons residing in the United Kingdom and obtaining the required nutrients from ordinary dietary sources. Available data do not permit an estimate of the ordinary range of variation but the allowances, estimated to be adequate for representative members of the several specified activity groups, may need to be increased for some members of each group. Blank spaces indicate lack of data, not absence of requirement. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison between species and does not necessarily imply a close correlation between nutrient need and body weight.

Required (R)

	Specifications / Nutrients per kg body weight per day	♂65 kg	♀56 kg	♂65 kg	♀56 kg	♂65 kg	♀56 kg	♂65 kg	♀56 kg	♂65 kg	♀65 kg	♀56 kg
		Over 65 yr	Over 60 yr	Sedentary		Moderately Active		Active		Very Active	Pregnancy[1]	Lactation
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
1	Water											
2	Calories,[2] metabolizable	35	36	39	38	46	45	54	54	65	42	54
3	Total food (dry)[3,4], g	7.5	7.7	8.3	8.1	9.9	9.6	10.8	10.8	13.2	9.1	11.5
4	Residue											
5	Protein[3,5], g	1.0	1.0	1.1	1.0	1.3	1.2	1.5	1.5	1.8	1.5	2.0
6	Carbohydrate[3,6], g	5.5	5.7	6.2	6.0	7.4	7.1	7.3	7.2	8.8	6.5	8.1
7	Fat[3,7], g	1.0	1.0	1.1	1.0	1.3	1.2	2.1	2.1	2.5	1.2	1.5
8	"Essential" fatty acids											
9	Vitamin A and β-carotene[8,9], µg	38.5	44.6	38.5	44.6	38.5	44.6	38.5	44.6	38.5	46.2	71.4
10	Ascorbic acid[9,10], mg	0.31	0.4	0.31	0.4	0.31	0.4	0.31	0.4	0.31	0.6	0.9
11	Biotin											
12	Choline											
13	Cobalamin[11]											
14	Vitamin D, calc. as calciferol[9,12], µg	R	R	R	R	R	R	R	R	R	0.16-0.23	0.36
15	Vitamin E[13]											
16	Folic acid group[14]											
17	Inositol											
18	Vitamin K[15]											
19	Niacin[3,16], mg	0.14	0.14	0.15	0.14	0.18	0.18	0.22	0.21	0.26	0.17	0.25
20	Pantothenic acid											
21	Para-aminobenzoic acid											
22	Pyridoxine group[17]											
23	Riboflavine[3], µg	22	21	23	23	28	27	32	32	40	25	36
24	Thiamine[3], µg	14	14	15	14	18	18	22	21	26	17	25

25	Calcium[9,18], mg	12	14	12	14	12	14	12	14	12	23	36
26	Chlorine											
27	Cobalt											
28	Copper											
29	Fluorine											
30	Iodine[9,19], µg	1.5	1.8	1.5	1.8	1.5	1.8	1.5	1.8	1.5	2.3	2.7
31	Iron[9,20], mg	0.185	0.214	0.185	0.214	0.185	0.214	0.185	0.214	0.185	0.231	0.268
32	Magnesium											
33	Manganese											
34	Molybdenum											
35	Phosphorus											
36	Potassium											
37	Silicon											
38	Sodium											
39	Sulfur											
40	Zinc											

/1/ Last half of pregnancy. Body weight assumed. /2/ Kilocalories, net utilizable for heat and total activity. The coefficients 4.0, 4.0 and 9.0 have been used for calculating the kilocalorie value of ingested grams of protein, carbohydrate and fat (5A,6A,7A). /3/ Calorie-correlated. /4/ Sum of 5A,6A, 7A, each carried to two decimal places. Rounding off of these, as presented, introduces apparent discrepancy between them and their sum. /5/ Allow protein Calories = 11% of 2A except in columns K, where 14%, and L, where 14.9%. /6/ Calculated by: 2A minus Calorie value of 5A and 7A, the remainder divided by 4 (cf Fn 2). /7/ Calculated by: 25% of 2A divided by 9 (cf Fn 2) for col. B-G and KL, and 35% similarly treated for HIJ. /8/ Allow 5000 I.U. of mixture/person. Average diet assumed to contain 20% by weight of preformed A (0.3 µg A alcohol = one I. U.) and 80% of β-carotene (0.6 µg = one I. U.), the mixture averaging 0.5 µg = one I. U. If dietary carotene is only 33% utilized (as is assumed) 0.9 µg of the mixture is worth one I. U. in effective activity. If diet contains only preformed A, allow 30% of the value in table; if only β-carotene, add 80% to value given. /9/ Neither weight- nor calorie-correlated? Allowance for ♂65 kg or ♀56 kg applies to adults of other body weights. /10/ Allow 20 mg/person. /11/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (B_{12a}, B_{12b}) which has approximately the same biological activity. /12/ 0.025 µg calciferol = one I. U. /13/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /14/ "Folic acid" a generic term for pteroylglutamic acid (PGA, folacin) and pteroylglutamates. Also known as vitamin M, B_c; L. casei factor, Norite eluate factor. /15/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione; 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /16/ Generic term for nicotinic acid (niacin), nicotinic acid amide (nicotinamide), pellagra preventive (P.P.) factor. /17/ Includes pyridoxine, pyridoxal, and pyridoxamine. /18/ Allow 0.8 g/person. /19/ Allow 100 µg/person. /20/ Allow 12 mg/person.

30. DAILY NUTRIENT ALLOWANCES: MAN, INFANCY AND CHILDHOOD, UNITED KINGDOM

In the absence of actually measured means and ranges the table presents estimates of the mean Calories of energy expenditure and mean intakes of various nutrients deemed sufficient to establish and maintain a good nutritional state in healthy persons residing in the United Kingdom and obtaining the required nutrients from ordinary[1] dietary sources. Available data do not permit an estimate of the ordinary range of variation but the allowances, estimated to be adequate for representative members of the several specified age groups, may need to be increased for some members of each group. Blank spaces indicate lack of data, not absence of requirement. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison between species and does not necessarily imply a close correlation between nutrient need and body weight.

	Specifications / Nutrients per kg body weight per day	Children to 12 yr					Children 13-20 yr			
		<1 yr	1-3 yr	4-6 yr	7-9 yr	10-12 yr	13-15 yr		16-20 yr	
		♂♀8 kg	♂♀12 kg	♂♀18 kg	♂♀27 kg	♂♀35 kg	♂49 kg	♀49 kg	♂63 kg	♀54 kg
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
1	Water									
2	Calories, metabolizable[2]	100	108	89	72	70	64	56	54	46
3	Total Food (dry)[3], g	21.5	23.3	19.2	15.5	15.0	13.8	12.2	11.7	10.0
4	Residue									
5	Protein[4,5], g	3.5	3.8	3.1	2.5	2.5	2.2	2.0	1.9	1.6
6	Carbohydrate[4,6], g	15.2	16.5	13.6	11.0	10.5	9.8	8.6	8.2	7.1
7	Fat[4,7], g	2.8	3.0	2.5	2.0	2.0	1.8	1.6	1.6	1.3
8	"Essential" fatty acids									
9	Vitamin A and β-carotene[8], µg	56[9]	125	83.3	55.5	43	30.6	30.6	39.7	46.3
10	Ascorbic acid, mg	1.2	1.2	0.8	0.7	0.7	0.6	0.6	0.5	0.6
11	Biotin									
12	Choline									
13	Cobalamin[10]									
14	Vitamin D_3 calc. as calciferol[11], µg	2.5	0.82	0.56	0.37	0.28	0.20	0.20	0.16	0.19
15	Vitamin E[12]									
16	Folic acid group[13]									
17	Inositol									
18	Vitamin K[14]									
19	Niacin[4,15], mg	0.37	0.42	0.33	0.30	0.29	0.27	0.22	0.22	0.18
20	Pantothenic acid									
21	Para-aminobenzoic acid									
22	Pyridoxine group[16]									
23	Riboflavine[4,17], µg	62	67	56	44	43	39	33	33	28
24	Thiamine[4,18], µg	37	42	33	30	29	27	22	22	18

25	Calcium, mg	125	83	56	37	34	29	27	22	18
26	Chlorine									
27	Cobalt									
28	Copper									
29	Fluorine									
30	Iodine[19], µg		12.5	8.3	5.6	4.3	3.1	3.1	2.4	2.8
31	Iron, mg	0.75	0.58	0.44	0.37	0.34	0.31	0.31	0.24	0.28
32	Magnesium									
33	Manganese									
34	Molybdenum									
35	Phosphorus									
36	Potassium									
37	Silicon									
38	Sodium									
39	Sulfur									
40	Zinc									

/1/ Including certain supplementary nutrients for infants and children (cod liver oil, vitamin A and D tablets, orange juice). /2/ Kilocalories, net utilizable for heat, total activity and growth. The coefficients 4.0, 4.0 and 9.0 have been used for calculating the kilocalorie value of ingested grams of protein, carbohydrate and fat (5A,6A,7A). /3/ Sum of 5A,6A,7A. /4/ Calorie-correlated. /5/ Allow protein Calories = 14% of 2A, and divide by 4 (cf. Fn 2). /6/ Calculated by: 2A minus Calorie value of 5A and 7A, the remainder divided by 4 (cf. Fn 2). /7/ Allow 25% (or more) of 2A and divide by 9 (cf. Fn 2). /8/ Allow 3000 I. U. of mixture (or 1500 I. U. of preformed vitamin A) per person, except for ages 16-20 years where allow 5000 I. U. of the mixture, or 2500 I. U. of A (See Fn 8 previous table). /9/ 56 µg preformed A (milk diet) during first year, equivalent to 188 µg of mixed A and β-carotene in ordinary diet (See Fn 8 previous table). /10/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (B_{12a}, B_{12b}) which has approximately the same biological activity. /11/ Allow 800 I. U./person for age 1 yr, 400 thereafter (0.025 µg calciferol = one I. U.) /12/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /13/ "Folic acid" a generic term for pteroylglutamic acid (PGA, folacin) and pteroylglutamates. Also known as vitamin M, B_c; L. casei factor, Norite eluate factor. /14/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione; 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /15/ Generic term for nicotinic acid (niacin), nicotinic acid amide (nicotinamide), pellagra preventive (P.P.) factor. Allow 4 µg/Calorie. /16/ Includes pyridoxine, pyridoxal, and pyridoxamine. /17/ Allow 0.6 µg/Calorie. /18/ Better correlated with non-fat Calories than with Calories in 2A. Allow 0.4 µg/Calorie (or 0.6 µg/non-fat Calorie). /19/ Allow 150 µg/person.

31. DAILY NUTRIENT ALLOWANCES: MAN, ADULT, U.S.A.

Nutrient needs vary from person to person as do other biological quantities, and are most suitably represented for any population by a mean value for each nutrient followed by a lower and an upper limit of the ordinary range of variation. In the absence of actually measured means and ranges, the table presents estimates -- estimated means for the values in lines 1,2,3,6,7, and 25, and estimates exceeding the upper limits of the ordinary range (estimate "d" of the 95% range; cf. Introduction) for remaining values. Estimates are for healthy persons living in the USA, and obtaining all required nutrients from ordinary dietary sources (but cf. Fn 26,30). To calculate all allowances for calorie-correlated items, use ideal weight (based on height) instead of actual weight, and correct for climate (Fn 6) and activity (Fn 7). For other nutrients use standard weight at top of column. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison between man and other species and does not necessarily imply a close or linear correlation between nutrient need and body weight.

Required (R)

	Specifications / Nutrients per kg body weight per day	Adults Normally Vigorous and Living in a Temperate Climate							
		25 yr		45 yr		65 yr		Pregnancy[1]	Lactation
		♂65 kg	♀55 kg	♂65 kg	♀55 kg	♂65 kg	♀55 kg	♀65 kg	♀55 kg
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
1	Water[2,3], ml	49	42	45	38	40	33	42	60
2	Calories, metabolizable[4,5,6,7]	49	42	45	38	40	33	42	60[8]
3	Total food[2,9], (dry), g	10.8⁻	9.0	9.8⁻	8.2	8.8	7.0	9.3	12.9
4	Residue[9]								
5	Protein[10], g	1	1	1	1	1	1	1.2	1.8
6	Carbohydrate[2,11], g	8.5	7.1	7.6	6.4	6.8	5.3	7.0	9.8
7	Fat[2,12], g	1.1-1.4	0.8-1.0	1.0-1.2⁺	0.7-0.9	0.9-1.1	0.6-0.8	0.9-1.2⁻	1.1-1.4
8	"Essential" fatty acids	R?	R?	R?	R?	R?	R?	R?	R?
9	Vitamin A and β-carotene[10,14], μg	41.5	49.1	41.5	49.1	41.5	49.1	46.8	78.5
10	Ascorbic acid[15,16], mg	1.15	1.25	1.15	1.25	1.15	1.25	1.55	2.75
11	Biotin[17]	R	R	R	R	R	R	R	R
12	Choline[18,19]								
13	Cobalamin[20]	R?	R?	R?	R?	R?	R?	R?	R?
14	Vitamin D[15], calc. as calciferol[21,22], μg	R	R	R	R	R	R	0.15	0.18
15	Vitamin E[18,23]								
16	Folic acid group[17,24]	R?	R?	R?	R?	R?	R?	R?	R?
17	Inositol[18]								
18	Vitamin K[17,25,26]	R	R	R	R	R	R	15.5[26]	R
19	Niacin[2,17,27], mg	0.25	0.22	0.21	0.18	0.18	0.18	0.31	0.27
20	Pantothenic acid[18,28]	R	R	R	R	R	R	R	R
21	Para-aminobenzoic acid								
22	Pyridoxine group[17,29,30], μg	15-31	18-36	15-31	18-36	15-31	18-36	15-31	18-36
23	Riboflavine[10,31], μg	25	26	25	26	25	26	31	46
24	Thiamine[2,32], μg	25	22	21	18	18	18	23	27

25	Calcium, mg	12	14	12	14	12	14	23	36
26	Chlorine[15,33], mg	93	88	93	88	93	88	88	88
27	Cobalt[34]	R?	R?	R?	R?	R?	R?	R?	R?
28	Copper[15,35], µg	18	21	18	21	18	21	23	27
29	Fluorine[18]								
30	Iodine[15,36], µg	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4
31	Iron[15], mg	0.18	0.21	0.18	0.21	0.18	0.21	0.23	0.27
32	Magnesium	R?	R?	R?	R?	R?	R?	R?	R?
33	Manganese	R?	R?	R?	R?	R?	R?	R?	R?
34	Molybdenum	R?	R?	R?	R?	R?	R?	R?	R?
35	Phosphorus[15,37], mg	18	21	18	21	18	21	23	36
36	Potassium	R	R	R	R	R	R	R	R
37	Silicon								
38	Sodium[15,33], mg	60	57	60	57	60	57	57	57
39	Sulfur	R	R	R	R	R	R	R	R
40	Zinc	R?	R?	R?	R?	R?	R?	R?	R?

/1/ Toward end of pregnancy. Weight = 55 kg, plus 10 kg of placenta, amniotic fluid, uterus, fetus, and additional body water. /2/ Calorie-correlated. /3/ Calorie-correlation breaks in excessively hot environment, the value rising to extremes of 100-200 ml/kg. /4/ Kilocalories, net utilizable for heat and total activity (and growth) = either $4.1P_a + 4.1C_a + 9.3F_a$ or $4.0P_i + 4.0C_i + 9.0F_i$ where PCF represent grams of protein, carbohydrate and fat and the subscripts "i" = ingested and "a" = virtually absorbed (i.e., ingested PCF minus fecal PCF). The coefficient 4.1 for P_a allows for loss of 22% of P_a Calories in the urine (urea, etc.). /5/ Adjustment for weight: If W, the ideal weight for a person's height, differs from the standard weight at the head of column, add ♂4.7%, or ♀5.5% to Calories for 10 kg underweight; subtract ♂3.5% or ♀5.5% for 10 kg overweight, or calculate total Calories as ♂152 ($W^{0.73}$), ♀123.4 ($W^{0.73}$). /6/ Adjustment for climate: Add 2% to Calories (columns B-G) for extreme northern U.S.A.; subtract 5% for southern U.S.A. No climate correction if mean annual temperature = 10° C. /7/ Adjustment for activity: For normally vigorous daily activity make no correction; for sedentary life, reduce Calories by 22%; for heavy work, add 20-25%; for heaviest work, add 50%. /8/ Assuming daily milk production of 850 ml, at energy expenditure of 130 Cal. per 100 ml milk produced. /9/ 3A = sum of 5A,6A,7A. "Residue" = lost in feces, = 8% of 5A + 3% of 6A + 5% of 7A, = approximately 3.5-4% of 3A. /10/ Correlated with body weight. /11/ Calculated by: 2A minus Calorie value of 5A and 7A, the remainder divided by 4 (cf. Fn 4). /12/ Taken as 20-25% of 2A, divided by 9 (cf. Fn 4). Proportion of Calories from fat taken as 30-35% for persons engaged in heavy work (cf. Fn 7). /14/ Allow 5000 I. U. per person, derived from average diet assumed to contain 11% by weight of preformed A (0.3 µg A alcohol = one I. U.) and 89% of β-carotene (0.6 µg = one I. U.). 0.54 µg of this mixture = one I. U. If dietary carotene is only 50% utilized (as is assumed), the mixture has an effective activity of 0.9 µg = one I. U. If diet contains only preformed A, allow 0.33 x value in the table; if only β-carotene, allow 1.33 x value given. /15/ Neither weight- nor calorie-correlated? Allowance for ♂65 kg or ♀55 kg applies to other adult body weights. /16/ Allow ♂75 mg ♀70mg/person. /17/ Some synthesis by intestinal flora. /18/ Definite requirement by man not conclusively demonstrated. /19/ Synthesized in adequate? amounts by transmethylation from methionine or betaine to ethanolamine. /20/ Generic term including cyanocobalamin (B_{12}) and its hydrogenation product (B_{12a},B_{12b}) which has approximately the same biological activity. /21/ Little need for adults except elderly persons and those whose habits prevent exposure to sunlight (night workers, nuns, etc). /22/ 0.025 µg calciferol = one I. U. /23/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /24/ "Folic acid" a generic term for pteroylglutamic acid (PGA; folacin) and pteroylglutamates. Also known as vitamin M, B_c; L. casei factor, Norite eluate factor. A daily dietary intake of less than 1 mg/person is probably sufficient. /25/ The antihemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione; 2-methyl-1, 4-napthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1, 4-naphthoquinone). /26/ Last month of pregnancy, as dietary supplement, to raise fetal blood prothrombin (vs birth hemorrhages). /27/ Generic term for nicotinic acid (niacin), nicotinic acid amide (nicotinamide), pellagra preventive (P. P.) factor. Some? formation from tryptophan. Allow 10 x 24A. /28/ Requirement practically certain, but not demonstrated. Component of Coenzyme A. Good diet supplies approximately 4 mg per 1000 Cal. /29/ Includes pyridoxine, pyridoxal, and pyridoxamine. /30/ Some evidence of defect in metabolism of pyridoxine in pregnancy; dietary supplement possibly of value? /31/ Allow 25 µg/g of protein. /32/ Allow 0.5 µg/Calorie. /33/ Assumed allowance: 10 g NaCl for physically active man, 8 g for moderately active woman; but 5 g NaCl is considered a liberal allowance except for persons who sweat profusely, as those engaged in heavy work. /34/ Required only as cobalamin? /35/ Allow 10% of 31A. /36/ Values given are probable requirement, greater in pregnancy? /37/ Allow 1.5 x 25A except for col. HI where allow 1 x 25A.

32. DAILY NUTRIENT ALLOWANCES: MAN, INFANCY AND CHILDHOOD, U.S.A.

The allowances listed are designed to maintain good nutrition of healthy persons in the U.S.A. In their application to individual persons, the allowances should be modified, if necessary, to take account of growth rate, physical development and state of nutrition. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison only, and does not necessarily imply a close or linear correlation between nutrient need and body weight.

Required (R)

Specifications / Nutrients per kg body weight per day	Children to 9 yr						Children 10-20 yr					
	1-3 mo[1]	4-9 mo[1]	10 mo-1 yr	1-3 yr	4-6yr	7-9 yr	10-12 yr		13-15 yr		16-20 yr	
	♂♀5 kg	♂♀8 kg	♂♀10 kg	♂♀12 kg	♂♀18 kg	♂♀27 kg	♂35 kg	♀36 kg	♂49 kg	♀49 kg	♂63 kg	♀54 kg
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
1 Water[3,4] ml	120	110	100	100	89	74	71	64	65	51	60	44
2 Calories, metabolizable[5]	120	110	100	100	89	74	71	64	65	51	60[2]	44[2]
3 Total food[4,6] (dry), g	25.3	22.6	20.5	20.4	18.2	15.2	14.7	12.3	13.3	10.4	12.3	9.1
4 Residue[6]												
5 Protein[7], g	3.5[8]	3.5[8]	3.5	3.3	2.8	2.2	2.0	1.9	1.7	1.6	1.6	1.4
6 Carbohydrate[4,9], g	17.5	15.1	13.4	13.5	12.2	10.3	10.1	8.6	9.3	7.0	8.6	6.1
7 Fat[4,10], g	4.0-4.7	3.7-4.3	3.3-3.9	3.3-3.9	3.0-3.5	2.5-2.9	2.4-2.8	2.1-2.5	2.2-2.5	1.7-2.0	2.0-2.3	1.5-1.7
8 "Essential" fatty acids	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
9 Vitamin A, and β-carotene[7,12], μg	54[13]	33.8[13]	81.0	90.0	75.0	70.0	66.6	64.7	55.1	55.1	42.9	50.0
10 Ascorbic acid, mg	6.0	3.8	3.0	2.9	2.8	2.2	2.1	2.1	1.8	1.6	1.6	1.5
11 Biotin[14]	R	R	R	R	R	R	R	R	R	R	R	R
12 Choline												
13 Cobalamin[15]	R	R	R	R	R	R	R	R	R	R	R	R
14 Vitamin D, calc. as calciferol[16,17], μg	2.0	1.25	1.0	0.83	0.55	0.37	0.28	0.28	0.20	0.20	0.16	0.18
15 Vitamin E[18]												
16 Folic acid group[14,19]	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
17 Inositol												
18 Vitamin K[14,20], μg	R	R	R	R	R	R	R	R	R	R	R	R
19 Niacin[14,21], mg	0.60	0.55	0.5	0.5	0.44	0.37	0.37	0.33	0.31	0.26	0.30	0.22
20 Pantothenic acid[22]	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
21 Para-aminobenzoic acid												
22 Pyridoxine group[14,23], μg	R	R	R	R	R	R	R	R	R	R	16-32	19-38
23 Riboflavine[7,24], μg	80	89	90	83	69	56	51	50	43	41	39	35
24 Thiamine[4,25], μg	60	55	50	50	44	37	36	33	32	26	30	22

25	Calcium[16], mg	120	100	100	83	56	37	34	33	28	26	22	24
26	Chlorine[16]	R	R	R	R	R	R	R	R	R	R	R	R
27	Cobalt[26]	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
28	Copper[16], µg	50	50	50	50	50	50	50	50	50	50	18-50	21-50
29	Fluorine												
30	Iodine[16,27], µg	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4
31	Iron[16], mg	1.2	0.75	0.6	0.58	0.42	0.38	0.34	0.34	0.31	0.31	0.24	0.28
32	Magnesium	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
33	Manganese	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
34	Molybdenum	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?
35	Phosphorus[16,28], mg	R	120	100	83	53	38	34	34	28	26	23	24
36	Potassium	R	R	R	R	R	R	R	R	R	R	R	R
37	Silicon												
38	Sodium[16]	R	R	R	R	R	R	R	R	R	R	R	R
39	Sulfur	R	R	R	R	R	R	R	R	R	R	R	R
40	Zinc	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?

/1/ No allowance data available for age 0-1 mo. When human milk (table 67, p.111) is the source of all nutrients, the constituents in 180 ml furnish an acceptable set of values for columns B, C, with notably lower allowances for protein (2+g), calciferol (0.02 µg), niacin (0.31 mg), pyridoxine (20 µg), thiamine (29 µg), calcium (59 mg), and iron (0.27 mg). /2/ Calorie allowance = 1.2 x age 25 values for boys, 1.05 x for girls (cf. preceding table). /3/ Allow 1 ml per kilocalorie. /4/ Calorie-correlated. /5/ Kilocalories, net utilizable for heat, total activity and growth = either $4.1P_a + 4.1C_a + 9.3F_a$, or $4.0P_i + 4.0C_i + 9.0F_i$, where PCF represent grams of protein, carbohydrate and fat and the subscripts "i" = ingested, and "a" = virtually absorbed (i.e., ingested PCF minus fecal PCF). The coefficient 4.1 for P_a allows for loss of 22% of P_a Calories in the urine (urea, etc.). /6/ 3A = sum of 5A,6A,7A. "Residue" = lost in feces, = 8% of 5A + 3% of 6A + 5% of 7A = approximately 3-4% of 3A. /7/ Correlated with body weight. /8/ Allow 2 to 3 g if human milk protein or if protein from other source has been effectively treated to increase digestibility. /9/ Calculated by: 2A minus Calorie value of 5A and 7a, the remainder divided by 4 (cf. Fn 5). /10/ Taken as 30-35% of 2A, divided by 9 (cf. Fn 5). /12/ Average diet assumed to contain 11% by weight of preformed A (0.3 µg A alcohol = one I. U.) and 89% of β-carotene (0.6 µg = I. U.). 0.54 µg of this mixture = one I. U. Allow per person: 1500 I. U. of this mixture up to age 1 yr, 2000 I. U., through age 3 yr, 2500 I. U., through age 6, 3500 I. U., through age 9, 4500 I. U., through age 12, 5000 I. U. thereafter. If dietary carotene is only 50% utilized (as is assumed) the mixture has an effective activity of 0.9 µg = one I. U. If diet contains only preformed A, allow 0.33 x value in table; if only β-carotene, allow 1.33. /13/ Assumed to be all preformed A alcohol(the values given represent µg of A alcohol: 54 µg equivalent to 180 I. U., and 33.8 µg equivalent to 113 I. U.; these in turn are equivalent to 300 I. U. and 187 I. U. mixed A alcohol and carotene). /14/ Some synthesis by intestinal flora. /15/ Generic term for cyanocobalamin (B_{12})and its hydrogenation product (B_{12a}, B_{12b}) which has approximately the same biological activity. /16/ Neither weight nor calorie-correlated? /17/ Allow 400 I. U./person (0.025 µg calciferol = one I. U.). /18/ Generic term for alpha-, beta-, delta-, and gamma-tocopherols. /19/ "Folic acid", generic term for pteroylglutamic acid (PGA; folacin) and pteroylglutamates. Also known as vitamin M, B_c; L. casei factor,Norite eluate factor. A daily dietary intake of less than 1 mg/person will probably cover any nutritional need. /20/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione; 2-methyl-1,4-naphthoquinone),and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). Give newborn infant single dose of 1 mg if supplementary K was not given antepartum to mother. /21/ Generic term for nicotinic acid (niacin), nicotinic acid amide (nicotinamide), pellagra preventive (P.P.) factor. Some formation from tryptophan. Allow 10 x 24A. /22/ Requirement practically certain, but not demonstrated. Component of Coenzyme A. Good diet supplies approximately 4 mg per 1000 Cal. /23/ Includes pyridoxine, pyridoxal and pyridoxamine. Allowance tentatively 2 mg/person? (=adult allowance). /24/ Allow 25µg/g of protein. /25/ Allow 0.5 µg/Calorie. /26/ Required only as cobalamin? /27/Values given are probable requirement, greater in adolescence? /28/ Allow 1.0 x 25A.

33. DAILY NUTRIENT ALLOWANCES: CAT

Values were derived from a basal diet composed of 40-50 percent meat products (lungs, spleen, hearts, kidneys, beef tongue gullets), with the remainder a mixture of soybean flour, skim milk powder, bone flour, and tomato puree. A failure of female cats to give birth to healthy, viable young, and/or to lactate occurs on this diet. The deficiency is overcome by supplementary feedings of fresh beef or liver or whole milk. The final body weight is greater in cats fed raw (unprocessed) mixtures than in those fed the processed form.

	Specifications / Nutrients per kg body weight per day	Growth		Maintenance	
		Raw Feed	Canned Feed	Raw Feed	Canned Feed
	(A)	(B)	(C)	(D)	(E)
1	Water				
2	Calories, metabolizable	123	103	76	87
3	Total feed				
4	Residue[1], g	0.6	0.5	0.38	0.43
5	Protein, g	11.7	9.8	7.25	8.3
6	Carbohydrate, g	11.7	9.8	7.25	8.3
7	Fat, g	3.2	2.7	2	2.3
8	"Essential" fatty acids				
9	Vitamin A, calc. as β-carotene[2], µg	81	67.2	49.8	57
10	Ascorbic acid				
11	Biotin				
12	Choline				
13	Cobalamin[3]				
14	Vitamin D, calc. as calciferol[4], µg	0.48	0.4	0.29	0.33
15	Vitamin E[5]				
16	Folic acid group[6]				
17	Inositol				
18	Vitamin K[7]				
19	Niacin[8], mg	2.3	2	1.4	1.6
20	Pantothenic acid				
21	Para-aminobenzoic acid				
22	Pyridoxine group[9]				
23	Riboflavine, mg	0.32	0.26	0.19	0.22
24	Thiamine, mg	0.05	0.04	0.03	0.04
25	Calcium, g	0.63	0.53	0.39	0.44
26	Chlorine				
27	Cobalt				
28	Copper				
29	Fluorine				
30	Iodine				
31	Iron				
32	Magnesium				
33	Manganese				
34	Phosphorus, g	0.4	0.33	0.24	0.28
35	Potassium				
36	Silicon				
37	Sodium				
38	Sulfur				
39	Zinc				

/1/ Fibre. /2/ 0.6 µg β-carotene = one I. U. /3/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /4/ 0.025 µg calciferol = one I. U. /5/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /6/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /7/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /8/ The term is used here as a generic term for nicotinic acid (niacin), nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /9/ Includes pyridoxine, pyridoxal, and pyridoxamine.

34. DAILY NUTRIENT ALLOWANCES: BEEF CATTLE

Values in this table are approximations to adequate allowances, intended to provide a safe margin above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species. For diets that supply these nutrient allowances, see table 50, Diets: Laboratory and Domestic Animals.

Required (R)

Specifications / Nutrients per kg body weight per day	Young[1]	Half-grown	Mature			
	♂♀180 kg	♂♀275 kg	♀500 kg			♂800 kg
	For Growth		For Maintenance	During Pregnancy	During Lactation[2]	For Maintenance[3]
(A)	(B)	(C)	(D)	(E)	(F)	(G)
1 Water, ml			60[4]	76[5]	76[5]	47[5]
2 Calories[6], metabolizable	71	56	33	33	51	32
3 Total feed[7], g	30	26	16	16	25	15
4 Residue						
5 Protein[8], g	2.3	1.5	0.7	0.7	1.3	0.8
6 Carbohydrate						
7 Fat						
8 "Essential" fatty acids						
9 Vitamin A[9], calc. as β-carotene, μg	0.13	0.13	0.13	0.13	0.60	0.13
10 Ascorbic acid,						
11 Biotin[10]	R[11]					
12 Choline	R					
13 Cobalamin[12]	R[11]					
14 Vitamin D[13], calc. as calciferol, μg	0.17[14]					
15 Vitamin E[15]	R	R	R	R	R	R
16 Folic acid group[16]						
17 Inositol						
18 Vitamin K[10,17]	R[11,]					
19 Niacin[10,18]						
20 Pantothenic acid[10]	R[11]					
21 Para-aminobenzoic acid						
22 Pyridoxine group[10,19]	R[11]					
23 Riboflavine[10,20], μg	27[11]					
24 Thiamine[10]	R[11]					
25 Calcium, mg	110	65	32	32	60	22
26 Chlorine, mg	28[21]	18[21]	30[22]	30[22]	30[23]	30[22]
27 Cobalt[24,25], μg	2	2	2	2	2	2
28 Copper	R	R	R	R	R	R
29 Fluorine						
30 Iodine	R	R	R	R	R	R
31 Iron	R	R	R	R	R	R
32 Magnesium, mg	13[26]	13[26]	R	R	R	R
33 Manganese[27], mg	0.50	0.52	0.32	0.32	0.50	0.30
34 Phosphorus, mg	85	54	32	30	50	22
35 Potassium	R	R	R	R	R	R
36 Silicon						
37 Sodium, mg	8[21]	5[21]	20[21]	20[22]	20[23]	20[22]
38 Sulfur[28]	R	R	R	R	R	R
39 Zinc	R	R	R	R	R	R

/1/ 30-35% mature weight. /2/ First 3-4 months after parturition. /3/ Moderate activity. /4/ 8 gal water daily. /5/ 10 gal water daily. /6/ Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the animal from food absorbed. If P, C, and F represent protein, carbohydrate and fat, ingested P,C,F - fecal P,C,F = virtually absorbed P,C,F. Grams of virtually absorbed P×4 + C×4 + F×9 = metabolizable Calories. These values are approximate only. The value for protein (=×4) allows for a 30% loss of virtually absorbed Calories in the urine (urea, hippuric acid, etc.). In animal husbandry, and in this table, metabolizable Calories are calculated from "T.D.N." ("total digestible nutrients") by multiplying grams T. D. N. by 4. /7/ Air-dried (90% dry weight). /8/ Digestible. /9/ 0.6 μg β-carotene = one I. U. /10/ Synthesized by ruminal bacteria. /11/ Young calves require this vitamin until ruminal function is established at 1-4 months of age. /12/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /13/ 0.025 μg calciferol = one I. U. Adequate vitamin D is normally supplied by exposure of animals to direct sunlight or by ingestion of sun-dried roughages. /14/ Based on 300 I. U. per 100 lb body weight per day. /15/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /16/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /17/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /18/ The term is used here as a generic term for nicotinic acid (niacin), nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /19/ Includes pyridoxine, pyridoxal, and pyridoxamine. /20/ Based on allowance of approximately 1 microgram per gram of dry matter consumed. /21/ Based on growing animal's requirement of 1.5 g NaCl and less than 5 g Cl per animal per day. /22/ Based on consumption of 1.75 lb NaCl per month, common on range or pasture. /23/ Based on 11 g Na and 15 g Cl as sufficient per animal per day for a cow producing 2 gal milk daily. /24/ Based on 0.1 mg per 100 lb body weight per day. /25/ Cobalt is probably required in the diet only as cobalamin. /26/ Based on 0.6 g magnesium per 100 lb body weight per day. /27/ Estimate on basis of 20 ppm of the ration. /28/ Sulfur is required in the diet only as methionine, or as methionine plus cystine.

35. DAILY NUTRIENT ALLOWANCES: DAIRY CATTLE

Values are approximations to adequate allowances, intended to provide a safe margin above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species. For diets that supply these nutrient allowances, see table 50, Diets: Laboratory and Domestic Animals.

Required (R); Not required (✗)

Nutrients per kg body weight per day \ Specifications	Young	Half-grown	Mature			
	♀182 kg	♀273 kg	♀545 kg			♂900 kg
	For Growth[1]		For Maintenance	During Pregnancy[2]	During Lactation[3]	For Maintenance
(A)	(B)	(C)	(D)	(E)	(F)	(G)
1 Water, ml	R[4]	R[4]	80[5]	100[6]	150[7]	R[4]
2 Calories[8], metabolizable	59	50	27	45	66	28
3 Total feed[9], g	27	25	15	22	25[10,11]	14
4 Residue						
5 Protein[12], g	2.1	1.4	0.6	1.1	2.1	0.7
6 Carbohydrate						
7 Fat						
8 "Essential" fatty acids						
9 Vitamin A, calc. as β-carotene[13], mg	0.13	0.13	0.13	0.19	0.19	0.13
10 Ascorbic acid						
11 Biotin	R[14]					
12 Choline	R					
13 Cobalamin[15,16]	R					
14 Vitamin D[17,18], calc. as calciferol, μg	0.22	0.22	0.22	0.22	0.22	0.22
15 Vitamin E[19]	R	R	R	R	R	R
16 Folic acid group[20]	R					
17 Inositol						
18 Vitamin K[21]	R[14?]					
19 Niacin[22]	✗					
20 Pantothenic acid	R[14]					
21 Para-aminobenzoic acid						
22 Pyridoxine group[23]	R[14]					
23 Riboflavine, μg	30[14]					
24 Thiamine	R[14]					
25 Calcium, mg	110	66	22	45	95	22
26 Chlorine, mg	R[4]	R[4]	28[24]	R[4]	76[25]	R[4]
27 Cobalt	R	R	R	R	R	R
28 Copper	R	R	R	R	R	R
29 Fluorine						
30 Iodine	R	R	R	R	R	R
31 Iron	R	R	R	R	R	R
32 Magnesium, mg	13[26]	13[26]	R	R	R	R
33 Manganese, mg	0.5	0.5	0.3	0.4	0.7	0.3
34 Phosphorus, mg	82	55	22	35	75	22
35 Potassium	R	R	R	R	R	R
36 Silicon						
37 Sodium, mg	R[4]	R[4]	18[24]	R[4]	49[25]	R[4]
38 Sulfur[27]	R[27]	R[28]	R[28]	R[28]	R[28]	R[28]
39 Zinc						

/1/ 30-35% mature weight. /2/ Late pregnancy. /3/ First 3-4 months after parturition; cow producing 40 lb milk daily (4% fat). /4/ Ad libitum. /5/ Based on 100 lb water daily per cow. /6/ Based on 110 lb water daily per cow. /7/ Based on 4.5 lb water for each lb of milk produced. /8/ Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the animal from the food absorbed. If P, C, and F represent protein, carbohydrate and fat, ingested P,C,F - fecal P,C,F = virtually absorbed P,C,F. Grams of virtually absorbed Px4 + Cx4 + Fx9 = metabolizable Calories. These values are approximate only. The value for protein (=4) allows for a 30% loss of virtually absorbed Calories in the urine (urea, hippuric acid, etc.). In animal husbandry, and in this table, metabolizable Calories are calculated from "T.D.N." ("total digestible nutrients") by multiplying grams T.D.N. by 4. /9/ Air-dried (90% dry weight). Differences in roughage intake permit wide variation in these values. /10/ This value is based on general experience and is lower than that calculated from the rule to allow 0.64 lb extra feed per lb milk. By this rule, a 545 kg cow giving 40 lb milk daily would be allowed 15 g/kg maintenance (column D) plus 21.6 g/kg for lactation, making a total of 37 g/kg. This constitutes a larger bulk than the ordinary lactating animal will consume. /11/ 1/4 to 1/2 nutrients would be in form of roughage feeds containing much cellulose. /12/ Digestible. /13/ 0.0006 mg β-carotene = one I. U. /14/ Young calves require this vitamin until ruminal function is established; this may vary from 1-4 months of age. /15/ A generic term for cyanocobalamin (vitamin B_{12}) and its hydrogenation product (variously known as B_{12a} and B_{12b}) which has approximately the same biological activity. /16/ Not required after one month of age. /17/ Based on 400 I. U. per 100 lb body weight. /18/ 0.025 μg calciferol = one I. U. /19/ A generic term for alpha-, beta-, delta-, gamma-tocopherols. /20/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, and Norite eluate factor. /21/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /22/ The term is used here as a generic term including nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive factor (P. P.), and anti-blacktongue factor. /23/ Includes pyridoxine, pyridoxal and pyridoxamine. /24/ Based on 2.1 g NaCl/100 lb body weight. /25/ Based on 2.1 g NaCl/100 lb body weight, plus an additional 3.6 g NaCl per 100 lb body weight for a cow producing 40 lb of milk daily. /26/ Based on 0.6 g magnesium/100 lb body weight per day, when the principal feeds consist of natural diets (grains and hays) other than milk. /27/ Very young animals should be supplied sulfur in organic compounds such as S-containing amino acids, and the vitamins thiamine and biotin. /28/ After ruminal function is established, elemental sulfur can satisfy the requirement, and thiamine and biotin are no longer needed in the diet (cf Fn 14).

36. DAILY NUTRIENT ALLOWANCES: DOG

Values are approximations to adequate requirements for normal growth, health and productivity. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species.

	Specifications / Nutrients per kg body weight per day	Young	Mature
		Growth	Maintenance
	(A)	(B)	(C)
1	Water		
2	Calories[1], metabolizable	150[2]	75[2]
3	Total feed, g	50	25-40
4	Residue		
5	Protein[3], g	2-5[4]	3-4[4]
6	Carbohydrate, g	26	17.6
7	Fat, g	7	1.3
8	"Essential" fatty acids		
9	Vitamin A, calc. as β-carotene[5], μg	120	59
10	Ascorbic acid		
11	Biotin[6,7]		0?
12	Choline, mg	55	33
13	Cobalamin[8], μg	1.5	0.55
14	Vitamin D, calc. as calciferol[9], μg	0.50	0.16
15	Vitamin E[10], mg	2.2[10]	
16	Folic acid group[11], μg	15	8
17	Inositol		0
18	Vitamin K[12]		0?
19	Niacin[13], mg	0.4	0.24
20	Pantothenic acid, mg	0.1	0.055
21	Para-aminobenzoic acid	0	0
22	Pyridoxine group[14], mg	0.055	0.022
23	Riboflavine, mg	0.09	0.044
24	Thiamine, mg	0.033	0.018
25	Calcium, mg	530[15]	260[16]
26	Chlorine, mg	440[17]	180
27	Cobalt, mg	0.05	0.05
28	Copper, mg	0.16	0.16
29	Fluorine, mg		0.08[18]
30	Iodine, mg	0.033	0.033
31	Iron, mg	1.3	1.3
32	Magnesium, mg	35	11
33	Manganese, mg	0.22	0.11
34	Phosphorus, mg	440[19]	220[20]
35	Potassium, mg	530[21]	220
36	Silicon		
37	Sodium, mg	60	120
38	Sulfur, mg		7[18]
39	Zinc, mg	0.42	0.11

/1/ Kilocalories. /2/ There is considerable variation, depending on size of the animal. /3/ Complete, balanced protein, free of toxic materials. /4/ Recommended allowance of 20% in diet. /5/ 0.6 μg β-carotene = one I.U. /6/ Needed only when avidin is in diet. /7/ Progressive paralysis cured by daily administration of 100 μg/kg body weight, which probably well exceeds daily need of healthy animals. /8/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /9/ 0.025 μg calciferol = one I.U. /10/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. A value of 1 has been reported. /11/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U,L. casei factor, Norite eluate factor. Values are based on the requirement of the fox. /12/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). Required when normal bile production is impaired. /13/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P.P.) factor, anti-blacktongue factor. /14/ Includes pyridoxine, pyridoxal and pyridoxamine. /15/ A value of 90 has been reported. /16/ A value of 45 has been reported. /17/ A value of 90 has been reported. /18/ Calculated from Wesson's salt mixture (0.7 g salt mixture/kg body weight per day). /19/ A value of 75 has been reported. /20/ A value of 35 has been reported. /21/ A value of 150 has been reported.

37. DAILY NUTRIENT ALLOWANCES: FOX AND MINK

Values are approximations to adequate requirements for normal growth, health and productivity. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species. For diets that supply the allowances in these columns, see table 50, Diets: Laboratory and Domestic Animals.

Required (R)

Specifications / Nutrients per kg body weight per day	Fox						Mink					
	Young 11 wk		3/4 grown 23 wk		Mature		Young 11 wk		3/4 grown 23 wk		Mature	
	♂2.3 kg	♀2.2 kg	♂4.7 kg	♀4.1 kg	♂5.7 kg	♀4.7 kg	♂0.59 kg	♀0.45 kg	♂0.95 kg	♀0.68 kg	♂1.04 kg	♀0.68 kg
	Growth				Maintenance		Growth				Maintenance	
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
1 Water												
2 Calories[1], metabolizable					122[2]	127[2]					271[3]	263[3]
3 Total feed, dry[4], g	73	62	42	37	25	27	100	111	86	100	83	100
4 Residue												
5 Protein, g	18	15	8	9	5	6	22	24	14	16	13	16
6 Carbohydrate[5]	R	R	R	R	R	R	R	R	R	R	R	R
7 Fat[6]												
8 "Essential" fatty acids												
9 Vitamin A, calc. as β-carotene[7], mg	0.08	0.06	0.04	0.04	0.03	0.03	0.10	0.11	0.09	0.10	0.08	0.10
10 Ascorbic acid												
11 Biotic												
12 Choline												
13 Cobalamin[8]												
14 Vitamin D	R	R	R	R	R	R	R	R	R	R	R	R
15 Vitamin E[9]												
16 Folic acid group[10], mg	0.014	0.012	0.008	0.007	0.005	0.005	0.020	0.022	0.017	0.021	0.015	0.021
17 Inositol												
18 Vitamin K[11]												
19 Niacin[12], mg	0.74	0.63	0.40	0.36	0.26	0.26	0.98	1.11	0.85	1.0	0.78	1.0
20 Pantothenic acid	0.56	0.50	0.32	0.29	0.21	0.19	0.80	0.89	0.68	0.79	0.63	0.79
21 Para-aminobenzoic acid												
22 Pyridoxine group[13], mg	0.08	0.07	0.05	0.04	0.03	0.03	0.10	0.13	0.09	0.12	0.09	0.12
23 Riboflavine, mg	0.14	0.12	0.08	0.07	0.05	0.05	0.20	0.22	0.17	0.21	0.15	0.21
24 Thiamine, mg	0.08	0.07	0.05	0.04	0.03	0.03	0.10	0.13	0.09	0.12	0.09	0.12
25 Calcium, g	0.43	0.36	0.26	0.21	0.16	0.15	0.39	0.40	0.34	0.40	0.35	0.40
26 Chlorine[14]	R	R	R	R	R	R	R	R	R	R	R	R
27 Cobalt												
28 Copper												
29 Fluorine												
30 Iodine												
31 Iron												
32 Magnesium												
33 Manganese												
34 Phosphorus, g	0.43	0.36	0.26	0.21	0.16	0.15	0.39	0.40	0.34	0.40	0.35	0.40
35 Potassium												
36 Silicon												
37 Sodium[15]	R	R	R	R	R	R	R	R	R	R	R	R
38 Sulfur												
39 Zinc												

/1/ Kilocalories. /2/ Based on 55 Cal/lb body weight. /3/ Based on 124 Cal/lb body weight. /4/ Usual wet ration assumed to be 34% dry weight. /5/ Foxes and minks have been maintained satisfactorily on a purified basal diet containing 66% sucrose. /6/ Fresh fat can be used in the diet to the extent of 5-10%. /7/ 0.0006 mg β-carotene = one I. U. /8/ A generic term including cyanocobalamin (B_{12}) and its hydrogenation product (B_{12a} or B_{12b}) which has approximately the same biological activity. /9/ A generic term for alpha-, beta-, gamma-, and delta-tocopherols. /10/ Folic acid is a generic term for pteroylglutamic acid (PGA; folacin) and pteroylglutamates. Also known as vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /11/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /12/ Generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P.P.) factor, anti-blacktongue factor. /13/ Includes pyridoxine, pyridoxal and pyridoxamine. /14/ 0.5% NaCl added to dry diet.

38. DAILY NUTRIENT ALLOWANCES: HORSE

Values are approximations to adequate allowances, intended to provide a safe margin above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species.

Required (R); Requirement questionable (?)

Specifications / Nutrients per kg body weight per day	Young	Half-grown	Mature				
	♂♀182 kg	♂♀363 kg	♂♀635 kg			♀635 kg	
	Growth		Maintenance	Medium Work	Hard Work	Pregnancy	Lactation
						Light Work	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
1 Water							
2 Calories[1], metabolizable	69	49	29	43	54	39	64
3 Total feed[2], g	30	22	13	19	23	17	25
4 Residue							
5 Protein[3], g	2.9	1.3	0.6	0.8	1.0	0.8	1.9
6 Carbohydrate[3], g	12.9	10.1	6.0	9.1	11.5	8.2	12.9
7 Fat[3], g	0.6	0.4	0.3	0.4	0.5	0.4	0.6
8 "Essential" fatty acids							
9 Vitamin A, calc. as β-carotene[4], mg	0.11	0.11	0.11	0.11	0.11	0.13	0.13
10 Ascorbic acid							
11 Biotin[5]	R	R	R	R	R	R	R
12 Choline							
13 Cobalamin[6]							
14 Vitamin D, calc. as calciferol[7], μg	0.2	0.2	0.2	0.2	0.2	0.2	0.2
15 Vitamin E[8]							
16 Folic acid group[9]	R	R	R	R	R	R	R
17 Inoaitol							
18 Vitamin K[10]							
19 Niacin[11], mg	0.10	0.10	0.10	0.10	0.10	0.13	0.13
20 Pantothenic acid[5]	R?	R?	R?	R?	R?	R?	R?
21 Para-aminobenzoic acid							
22 Pyridoxine group[12]	R	R	R	R	R	R	R
23 Riboflavine[5]	R	R	R	R	R	R	R
24 Thiamine[5]	R	R	R	R	R	R	R
25 Calcium, mg	113	55	20	28	32	31	60
26 Chlorine	R	R	R	R	R	R	R
27 Cobalt	?	?	?	?	?	?	?
28 Copper	?	?	?	?	?	?	?
29 Fluorine							
30 Iodine	R	R	R	R	R	R	R
31 Iron							
32 Magnesium	R	R	R	R	R	R	R
33 Manganese							
34 Phosphorus, mg	96	51	22	31	36	40	50
35 Potassium							
36 Silicon							
37 Sodium	R	R	R	R	R	R	R
38 Sulfur							
39 Zinc							

/1/ Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the animal from the food absorbed. If P, C, and F represent protein, carbohydrate and fat, ingested P,C,F - fecal P,C,F = virtually absorbed P,C,F. Grams of virtually absorbed $Px^4 + Cx4 + Fx9$ = metabolizable Calories. These values are approximate only. The value for protein (=x4) allows for a 30% loss of virtually absorbed Calories in the urine (urea, hippuric acid, etc.). In animal husbandry, and in this table, metabolizable Calories are calculated from "T. D. N." ("total digestible nutrients") by multiplying grams T. D. N. by 4. /2/ Air-dried (90% dry weight). /3/ Digeatible. /4/ 0.0006 mg β-carotene = one I. U. /5/ Probably synthesized by the horse. /6/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /7/ 0.025 μg calciferol = one I. U. Normally supplied by exposure to direct sunlight or by ingestion of sun-dried roughages. /8/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /9/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /10/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-napbthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /11/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /12/ Includes pyridoxine, pyridoxal and pyridoxamine.

39. DAILY NUTRIENT ALLOWANCES: MONKEY

Values are for Macaca mulatta. They are approximations to adequate allowances, and are applicable to juvenile or adolescent as well as mature monkeys. The presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species.

Required (R)

	Specifications / Nutrients per kg body weight per day	Rhesus Monkey, Growth and Maintenance: Minimum Requirement	Rhesus Monkey, Growth and Maintenance: Daily Allowance[1]
	(A)	(B)	(C)
1	Water		
2	Calories[2], metabolizable	41-54[3]	158[3]
3	Total feed, g		40
4	Residue		
5	Protein, g		7.2
6	Carbohydrate, g		28.4
7	Fat, g	1.6-2.0	
8	"Essential" fatty acids		?
9	Vitamin A, calc. as β-carotene[4], μg	R	36
10	Ascorbic acid, mg	1	4
11	Biotin, μg	5	8
12	Choline, mg		40[5]
13	Cobalamin[6], μg		?
14	Vitamin D, calc. as calciferol[7], μg	R	0.32
15	Vitamin E[8], mg	R	2.0
16	Folic acid group[9,10], μg	35-50	80
17	Inositol, mg		40
18	Vitamin K[11], μg		40
19	Niacin[12,13], mg	2-3[14]	1.0
20	Pantothenic acid[15], mg	<1	0.8
21	Para-aminobenzoic acid, mg		12.0
22	Pyridoxine group[15,16], μg	400[14]	140
23	Riboflavine[15], μg	25-30	140
24	Thiamine, μg	15	140
25	Calcium, mg	<60	155
26	Chlorine, mg		230
27	Cobalt[17], μg		19
28	Copper, μg		480
29	Fluorine, μg		40
30	Iodine, mg		0.6
31	Iron, mg		5
32	Magnesium, mg		10
33	Manganese, mg		1.6
34	Phosphorus, mg		170
35	Potassium, mg		135
36	Silicon		?
37	Sodium, mg		130
38	Sulfur, mg		14
39	Zinc, mg		0.9

/1/ For a diet that will supply the nutrients in this column, see table 50, Diets: Laboratory and Domestic Animals. /2/ Kilocalories. These values represent the approximate amount of food energy available to and capable of use by the animal from the food absorbed. /3/ For the adolescent monkey. /4/ 0.6 μg β-carotene = one I. U. /5/ 25 mg has been used with satisfactory results. /6/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /7/ 0.025 μg calciferol = one I.U. /8/ A generic term for alpha-, beta-, delta-, gamma-tocopherols. /9/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /10/ Increase in allowance above the minimum value has not produced any beneficial effects except in deficiencies of pantothenic acid, pyridoxine and riboflavine, or when the animal has first been depleted of folacin. /11/ A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone) and synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone). /12/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-black-tongue factor. /13/ Requirement depends somewhat on tryptophan content of the diet. /14/ Value derived from repletion (therapeutic) type experiment. /15/ Exact requirement difficult to determine since a deficiency of the vitamin elicits a requirement for an unidentified factor, the "monkey anti-anemia factor", or greatly increases requirement for folacin. /16/ Includes pyridoxine, pyridoxal and pyridoxamine. /17/ Need except as cobalamin not known.

40. DAILY NUTRIENT ALLOWANCES: RAT

Values are approximations to adequate allowances, intended to provide a safe margin above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison between species, and does not necessarily imply a close correlation between nutrient need and body weight within the species.

Required (R); Not required (✗)

	Specifications / Nutrients per kg body weight per day	White Rat				
		Young	Half-grown	Mature		
		♂♀29 da	♂51 da; ♀59 da	♂108 da; ♀120 da		
		♂♀0.05 kg	♂♀0.15 kg	♂0.30 kg ♀0.20 kg	♀0.30 kg	♀0.30 kg
		Growth		Maintenance	Pregnancy	Lactation
	(A)	(B)	(C)	(D)	(E)	(F)
1	Water	R	R	R	R	R
2	Calories, metabolizable	♂290; ♀280	♂195; ♀180	♂113; ♀135	R	R
3	Total feed, g	100	75	50		
4	Residue,	✗	✗	✗	✗	✗
5	Protein, g	R	19	R	R	R
6	Carbohydrate	✗	✗	✗	✗	✗
7	Fat[1]	✗	✗	✗	✗	✗
8	"Essential" fatty acids	R	R	R	R	R
9	Vitamin A[2], calc. as β-carotene, mg	0.01[3]	0.01[3]	0.01[3]	R	R
10	Ascorbic acid	✗	✗	✗	✗	✗
11	Biotin	✗	✗	✗	✗	✗
12	Choline, mg	80[3]	40[3]	40[3]	50	60
13	Cobalamin[4]	R	R?	R?	R?	R
14	Vitamin D	✗	✗	✗	✗	✗
15	Vitamin E, mg	3.0[3]	1.2[3]	1.2[3]	1.5	1.5
16	Folic acid group[5]	✗[6]	✗[6]	✗[6]	✗[6]	✗[6]
17	Inositol	✗[7]	✗[7]	✗[7]	✗[7]	✗[7]
18	Vitamin K[8]	✗	✗	✗	✗	✗
19	Niacin[9]	✗	✗	✗	✗	✗
20	Pantothenic acid, mg	1.0	0.30	0.36	0.45	0.45
21	Para-aminobenzoic acid	✗	✗	✗	R	R
22	Pyridoxine group[10], mg	0.30	0.35	0.04[3]	0.09	0.07
23	Riboflavine, mg	0.30	0.27	0.1[3]	0.04	0.02
24	Thiamine, mg	0.2	0.05	0.05[3]	0.05	0.05
25	Calcium, g	0.8-1.0	0.25-0.35	0.16-0.2	0.16-0.2	0.16-0.2
26	Chlorine, mg	100	30	20	20	20
27	Cobalt[11], µg	✗	✗	✗	✗	✗
28	Copper, mg	2	1	1	2	2
29	Fluorine	✗?	✗?	✗?	✗?	✗?
30	Iodine, mg	0.026	0.026	0.008	0.008	0.008
31	Iron, mg	5	5	5	20	20
32	Magnesium, mg	5	5	5	5	5
33	Manganese, mg	10	7	2	3	3
34	Phosphorus, g	0.7-0.9	0.25-0.3	0.14-0.18	0.14-0.18	0.14-0.18
35	Potassium, mg	♂300; ♀160	♂80; ♀50	60	60	200
36	Silicon	✗	✗	✗	✗	✗
37	Sodium, g	0.5	0.3	0.2	0.2	0.2
38	Sulfur[12]	R	R	R	R	R
39	Zinc, mg	0.8	0.35	R	R	R

/1/ There is no evidence that fat per se is needed except as a means of supplying essential fatty acids. /2/ 0.0006 mg β-carotene = one I. U. /3/ Values raised 20% to provide margin above minimum requirements submitted by Brown, R. A. /4/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /5/ Folic acid is not a chemical entity but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /6/ Essential when "sulfa" drugs are administered, or when diet is low in protein. /7/ Some authorities claim a requirement is indicated. /8/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione; 2-methyl-1,4-naphthoquinone) and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /9/ A generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /10/ Includes pyridoxine, pyridoxal and pyridoxamine. /11/ The cobalt present in vitamin B_{12} takes care of the entire cobalt requirement of the rat as far as is known; inorganic cobalt is not utilized nor required. /12/ Organic sulfur (menthionine) satisfies all the sulfur requirements; inorganic sulfur is not required.

41. DAILY NUTRIENT ALLOWANCES: GERM-FREE RAT, CHICKEN

The allowances in this table are based on diets demonstrated to be adequate for and, in some cases, definitely in excess of, the needs of the animal. All elements in the diet were steam sterilized (30 min., 121°C). Sterility of environment was maintained in the case of the germ-free[1] animals. All other conditions were identical for both the germ-free and control animals.

Specifications / Nutrients per kg body weight per day	Chicken[2]		Rat, White			
	Bantam	White Leghorn	Young		Young Adult[3]	
	28 da	28 da	10 da			
	♂♀0.11 kg	♂♀0.25 kg	♂♀0.02 kg[4,5]	♂♀0.01 kg[6]	♂♀0.20 kg	
	Controls and Germ-free		Controls	Germ-free	Controls	Germ-free
(A)	(B)	(C)	(D)	(E)	(F)	(G)
1 Water, ml	200	120	400	350	90	110
2 Calories[7], metabolizable	580	330	520	1200	190	190
3 Total feed, g	140	80	100	150	50	50
4 Residue, g		5	0	0	0	2
5 Protein, g	48	28	48	43	13	13
6 Carbohydrate, g	65	40	16	15	27	27
7 Fat, g	11	5	30	100	3	3
8 "Essential" fatty acids						
9 Vitamin A[8], calc. as β-carotene, μg	320	190	1.2	12	240	240
10 Ascorbic acid, mg	270	160	3.5	25		50?
11 Biotin, μg	55	32	42	40	50	50
12 Choline, mg	270	160		50	4	4
13 Cyanocobalamin[9] -g						
14 Vitamin D, μg	1.2[10]	0.6[10]	0.07[11]	11[11]	1[11]	1[11]
15 Vitamin E[12], mg	35	20			25	25
16 Folacin[13], mg	1.4	0.8	0.16	0.58	0.4	0.4
17 Inositol, mg	140	80			50	50
18 Vitamin K[14], mg	7	4			5	5
19 Nicotinamide, mg	7	4	9	2.5	5	5
20 Pantothenic acid[15], mg	27	16	2.3	12	12	12
21 Para-aminobenzoic acid						
22 Pyridoxine, mg	3	1.6	0.5	5	1.4	1.4
23 Riboflavin, mg	4	2.4	0.01	6	1.3	1.3
24 Thiamine, mg	8	5	4	5	0.4	0.4
25 Calcium, g	1.1	0.65	1.0	1.3	0.41	0.41
26 Chlorine, mg	240	140			90	90
27 Cobalt, mg	1	0.6			0.3	0.3
28 Copper, mg	8	5		1.5	3	3
29 Fluorine, mg	1	0.6			0.3	0.3
30 Iodine, mg	2	1			0.8	0.8
31 Iron, mg	80	50	3.5	25	25	25
32 Magnesium, mg	60	35	150	80	20	20
33 Manganese, mg	25	14		0.05	9	9
34 Phosphorus, g	1.1	0.63	1.0	0.8	0.4	0.4
35 Potassium, g	0.8	0.5	0.5	0.7	0.3	0.3
36 Silicon						
37 Sodium, g	0.7	0.4	0.4	0.5	0.25	0.25
38 Sulfur, mg					0.7	0.7
39 Zinc, mg	1.6	0.9				

/1/ A discussion of the meaning of "germ-free", and a description of the methods used in raising germ-free animals will be found in the Lobund reports of the University of Notre Dame. /2/ It should be noted that each of these columns (B and C) contains data for both control and germ-free chickens. No difference was found between the daily nutrient allowance of controls and germ-free chickens in the case of the two breeds, bantam and white leghorn. For a diet that will supply the nutrients listed in these columns, see table 50, Diets: Laboratory and Domestic Animals. /3/ Nutrient allowances for growth, maintenance, reproduction. /4/ Suckling rats. /5/ The values in this column are based on the chemical composition of normal rat milk. /6/ Artificially fed. /7/ Kilocalories, calculated from the following standards: protein, 4.2 calories per gram; carbohydrate, 4.15 calories per gram; and fat, 9.4 calories per gram. /8/ One I. U. = 0.6 μg β-carotene. /9/ Vitamin B_{12}. /10/ Calculated as D_3. One International Chick Unit = 1.33 A.O.A.C. units = 0.025 μg vitamin D_3 (7-dehydrocholesterol). /11/ Calculated as calciferol. One I. U. = 0.025 μg calciferol. /12/ As α-tocopherol. /13/ Folic acid; pteroylglutamic acid. /14/ As menadione, 2-methyl-1, 4-naphthoquinone. /15/ As calcium pantothenate.

42. DAILY NUTRIENT ALLOWANCES: CERTAIN RODENTS

Values are approximations to adequate allowances, intended to provide a safe margin above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species.

Required (R); Not required (✗)

	Specifications / Nutrients per kg body weight per day	Cotton Rat	Hamster	Mouse
		Young		
		0.025 kg	0.025 kg	0.025 kg
		Growth		
	(A)	(B)	(C)	(D)
1	Water, ml	R	R	182
2	Calories, utilizable[1]	620	645	637
3	Total feed, g	150	150	140
4	Residue, g		4.8[2]	
5	Protein, g	38[3]	32[3]	42[3]
6	Carbohydrate, g	100[4]	104[5]	70
7	Fat, g	7.5[6]	11.2[7]	21
8	"Essential" fatty acids, g			0.1[4]
9	Vitamin A, calc. as β-carotene[8], mg	0.9[9]	1.1[10]	0.84[11]
10	Ascorbic acid	✗	✗	✗
11	Biotin, mg	0.02	0.02	0.03[12]
12	Choline, mg	160	640	210
13	Cobalamin[13], mg		✗?	4[14]
14	Vitamin D, calc. as calciferol[15], μg	59	6.8[10]	3.5[11]
15	Vitamin E[16], mg		4.0	7[11]
16	Folic acid group[17], mg	0.32	0.32	0.7
17	Inositol, mg	160	400	✗
18	Vitamin K[18], mg		4.8	1.4[11]
19	Niacin[19,20], mg	4.0	8.0	7
20	Pantothenic acid, mg	3.2	1.6[21]	14

	Specifications / Nutrients per kg body weight per day	Cotton Rat	Hamster	Mouse
		Young		
		0.025 kg	0.025 kg	0.025 kg
		Growth		
	(A)	(B)	(C)	(D)
21	Para-aminobenzoic acid, mg	48	160	✗
22	Pyridoxine group[22], mg	0.40	1.9	1.4
23	Riboflavine, mg	0.48	2.6	2.8
24	Thiamine, mg	0.40	1.3	1.4
25	Calcium, g			0.9
26	Chlorine, mg			800
27	Cobalt, μg			400
28	Copper, mg			0.7
29	Fluorine, mg			0.6
30	Iodine, mg			1.3
31	Iron, mg			30
32	Magnesium, mg			66
33	Manganese, mg			5.6
34	Mineral salts, g	6.4	6.4	
35	Phosphorus, g			0.9[4]
36	Potassium, mg			590
37	Silicon			
38	Sodium, g			0.52
39	Sulfur			
40	Zinc, mg			0.3
41	Unknown factors	R[23]	R[23]	

/1/ Kilocalories. These values represent the approximate amount of food energy available to and capable of use from the food absorbed. /2/ Cellulose. /3/ Casein. /4/ Sucrose. /5/ Glucose. /6/ Corn oil. /7/ Lard. /8/ 0.0006 mg β-carotene = one I.U. /9/ As A and D oil (3000 I. U. A, 400 I. U. D per gram). /10/ As A and D oil (1200 I. U. A, and 170 I. U. D per gram). /11/ Probably not required in short-term experiments with offspring from well nourished mice. /12/ Possibly not required in diets of ordinary composition. /13/ A generic term including cyancobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /14/ 0.04 mg = minimum requirement. /15/ 0.025 μg calciferol = one I. U. /16/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /17/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /18/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone) and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /19/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /20/ Response to nicotinamide inversely proportional to tryptophan content of diet. /21/ As calcium pantothenate. /22/ Includes pyridoxine, pyridoxal, pyridoxamine. /23/ 1:20 liver extract.

43. DAILY NUTRIENT ALLOWANCES: SHEEP

Values are approximations to adequate allowances, intended to provide a safe margin above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species. For diets that supply these nutrient allowances, see table 50, Diets: Laboratory and Domestic Animals.

Required (R)

	Specifications / Nutrients per kg body weight per day	Young	Half-grown	Mature			
		♂♀23 kg	♂♀36 kg	♂♀59 kg			♂♀79 kg
		Growth		Maintenance	Pregnancy	Lactation	Maintenance
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Water	60	50	62	62	92	69
2	Calories[1], metabolizable	95	101	60	70	85	60
3	Total feed[2], g	41	43	29	32	37	26
4	Residue						
5	Protein[3], g	3.4	2.9	1.6	1.8	2.3	1.3
6	Carbohydrate	21	22	14	16	19	12
7	Fat	0.65	0.62	0.39	0.50	0.63	0.33
8	"Essential" fatty acids						
9	Vitamin A, calc. as β-carotene[4], mg	0.13	0.12	0.12	0.13	0.14	0.12
10	Ascorbic acid						
11	Biotin						
12	Choline						
13	Cobalamin[5], μg			1.7	1.7	1.7	
14	Vitamin D, calc. as calciferol[6], μg	0.2	0.2	0.2	0.2	0.2	0.2
15	Vitamin E[7], mg	0.3	0.3	0.3	0.3	0.3	0.3
16	Folic acid group[8]						
17	Inositol						
18	Vitamin K[9]						
19	Niacin[10]						
20	Pantothenic acid[11]	R					
21	Para-aminobenzoic acid						
22	Pyridoxine group[12]	R					
23	Riboflavine[11]	R					
24	Thiamine[11]	R					
25	Calcium, mg	110	94	58	75	110	50
26	Chlorine, mg	150[12]	150[12]	150[12]	150[12]	150[12]	150[12]
27	Cobalt, mg	0.002	0.002	0.002[13]	0.002[13]	0.002[13]	0.001[13]
28	Copper, mg	0.2	0.2	0.2[14]	0.2[14]	0.2[14]	0.2[14]
29	Fluorine						
30	Iodine, mg				0.02[15]		
31	Iron	R	R	R	R	R	R
32	Magnesium						
33	Manganese						
34	Phosphorus, mg	90	82	45	60	80	40
35	Potassium						
36	Silicon						
37	Sodium, mg	100[12]	100[12]	100[12]	100[12]	100[12]	100[12]
38	Sulfur						
39	Zinc						

/1/ Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the animal from the food absorbed. If P, C, and F represent protein, carbohydrate and fat, ingested P,C,F - fecal P,C,F = virtually absorbed P,C,F. Grams of virtually absorbed $Px4 + Cx4 + Fx9$ = metabolizable Calories. These values are approximate only. The value for protein ($=x4$) allows for a 30% loss of virtually absorbed Calories in the urine (urea, hippuric acid, etc.). In animal husbandry, and in this table, metabolizable Calories are calculated from "T. D. N." ("total digestible nutrients") by multiplying grams T.D.N. by 4. /2/ Air-dried (90% dry weight). /3/ Digestible. /4/ 0.0006 mg β-carotene = one I. U. /5/ A generic term including cyanocobalamin and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /6/ 0.025 μg calciferol = one I. U. /7/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. May help prevent muscular dystrophy in lambs and may be needed for normal reproduction. /8/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /9/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /10/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /11/ Synthesized by ruminal bacteria, but young lambs may need supplements in diet. /12/ Based on 1 lb/130 lb body weight/month. /13/ Based on about 0.1 mg/adult sheep/day. /14/ Based on 10 mg copper/adult sheep/day. /15/ Recommended during gestation period in form of iodized salt in the goiter belt.

44. DAILY NUTRIENT ALLOWANCES: SWINE

Values are approximations to adequate requirements for normal growth, health and productivity. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species. For diets that supply these nutrient allowances, see table 50, Diets: Laboratory and Domestic Animals.

Required (R); Not required (✗)

	Specifications / Nutrients per kg body weight per day	Young[1]	Half-grown	Mature	
		♂♀68 kg	♂♀113 kg	♂♀227 kg	♀205 kg
		Growth		Breeding♂ Pregnancy	Lactation
	(A)	(B)	(C)	(D)	(E)
1	Water				
2	Calories[2], metabolizable	140	100	45	80
3	Total feed[3], g	45	33	15	28
4	Residue				
5	Protein[4], g	5.9	4.0	2.1	3.9
6	Carbohydrate				
7	Fat	R	R	R	R
8	"Essential" fatty acids				
9	Vitamin A, calc. as β-carotene[5], mg	0.045[5]	0.045[5]	0.09	0.16
10	Ascorbic acid[6]	✗	✗	✗	✗
11	Biotin[7]				
12	Choline[8]	R			
13	Cobalamin[9], μg	0.5[10]	R[10]	R[10]	R[10]
14	Vitamin D, calc. as calciferol[11], μg	0.23	0.17	0.08	0.14
15	Vitamin E[12]	R[13]	R[13]	R[13]	R[13]
16	Folic acid group[14]	R[15]			
17	Inositol				
18	Vitamin K[7,16]				
19	Niacin[17], mg	0.5	0.37	0.17	0.31
20	Pantothenic acid, mg	0.45	0.34	0.15	0.27
21	Para-aminobenzoic acid[6]				
22	Pyridoxine group[18], mg	<0.11			
23	Riboflavine, mg	0.10	0.07	0.04	0.07
24	Thiamine, mg	0.05	0.04	0.02	0.03
25	Calcium, mg	250	180	85	150
26	Chlorine[13,19], mg	140	100	40	80
27	Cobalt,				
28	Copper[20]	R	R	R	R
29	Fluorine[6]				
30	Iodine, μg	<4	<4	<4	<4
31	Iron	R	R	R	R
32	Magnesium	R	R	R	R
33	Manganese	R	R	R	R
34	Phosphorus, mg	150	110	50	90
35	Potassium, mg	50-100	50-100	50-100	50-100
36	Silicon[6]				
37	Sodium[19], mg	90	65	33	55
38	Sulfur[6]				
39	Zinc	R	R	R	R

/1/ 30-35% mature weight. /2/ Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the animal from the food absorbed. If P, C, and F represent protein, carbohydrate and fat, ingested P,C,F - fecal P,C,F = metabolizable Calories. These values are approximate only. The value for protein (=x4) allows for a 30% loss of virtually absorbed Calories in the urine (urea, hippuric acid, etc.). In animal husbandry, and in this table, metabolizable Calories are calculated from "T. D. N." ("total digestible nutrients") by multiplying grams T. D. N. by 4. /3/ Air-dried (90% dry weight). /4/ Crude protein. /5/ 0.0006 mg β-carotene = one I. U. A value of 0.09 mg/kg body weight per day has been suggested for growth of swine. /6/ Supplement to natural ration not necessary. /7/ Synthesized by intestinal flora. /8/ Baby pigs require 0.1% choline in diet. /9/ A generic term including cyanocobalamin (vitamin B_{12}), and its hydrogenation product (known variously as B_{12a} and B_{12b}) which has approximately the same biological activity. /10/ Necessary for growth and reproduction. /11/ 0.025 ug calciferol = one I. U. /12/ A generic term including alpha-, beta-, delta-, and gamma-tocopherols. /13/ For proper muscular nutrition. /14/ Folic acid is not a chemical entity, but a generic term for a group of factors including pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, and Norite eluate factor. /15/ Swine synthesize most if not all they need. /16/ The anti-hemorrhagic factor. A generic term including vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /17/ The term is used here as a generic term including nicotinic acid (niacin) and, nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor; and anti-blacktongue factor. The requirement may be uncertain since it depends on the protein intake. /18/ Includes pyridoxine, pyridoxal, and pyridoxamine. /19/ In NaCl. /20/ Copper requirement approximately 5% iron requirement.

45. DAILY NUTRIENT ALLOWANCES: CHICKEN

Values are approximations to adequate requirements for normal growth, health and productivity. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species. For diets that supply the allowances in these columns, see table 50, Diets: Laboratory and Domestic Animals.

	Specifications / Nutrients per kg body weight per day	Single Comb White Leghorn					Rhode Island Red				
		Young	Half-grown	Mature			Young	Half-grown	Mature		
		3-4 wk	10-12 wk	36-52 wk			3 wk	11-12 wk	36-52 wk		
		♂♀0.23kg	♂♀0.91 kg	♀1.82 kg			♂♀0.23 kg	♂♀1.25 kg	♀2.5 kg		
		Growth	Growth	Maintenance	Laying	Breeding	Growth	Growth	Maintenance	Laying	Breeding
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(B)	(I)	(J)	(K)
1	Water, ml	575[1]	200[2]	110[3]	110[3]	110[3]	575[1]	140[2]	80[3]	80[3]	80[3]
2	Calories[4], metabolizable	300		150	150	150					
3	Total feed, g	132	78	39	60	60	124	80	35	50	50
4	Residue, g	5			3	3	6		3	3	
5	Protein[5], g	26.0	12.5	6.0	9.0	9.0	24.0	12.7	?	7.4	7.4
6	Carbohydrate, g	50			25	25	70	32	18	23	
7	Fat[6], g	3.0	1.6	1.0	1.2	1.2	3.2	1.5	1.0	1.0	1.0
8	"Essential" fatty acids										
9	Vitamin A, calc. as β-carotene[7], mg	0.21	0.12	?	0.16	0.16	0.20	0.13	?	0.13	0.13
10	Ascorbic acid[8]										
11	Biotin, µg	12	7		8	7	11	7		7	6
12	Choline, mg	175	111		56	56	163	103		50	50
13	Cobalamin[9], µg	1.2				0.2	1.2				0.2
14	Vitamin D, calc. as cryst. D_3[10], µg	0.66	0.38	?	0.75	0.75	0.62	0.40	?	0.62	0.62
15	Vitamin E[11], mg	2.6	1.4				2.8	1.3			
16	Folic acid group[12], mg	0.07	0.04		0.015	0.021	0.07	0.04		0.01	0.02
17	Inositol[8]										
18	Vitamin K[13], µg	52	28				55	26			
19	Niacin[14], mg	3.5	1.1			0.45	3.3	1.0			
20	Pantothenic acid, mg	1.23	0.73	0.22	0.28	0.55	1.15	0.74		0.23	0.46
21	Para-aminobenzoic acid[8]										
22	Pyridoxine group[15], mg	0.38	0.24	?	0.17	0.17	0.36	?		0.14	0.14
23	Riboflavine, mg	0.38	0.14	?	0.13	0.23	0.36	0.14	?	0.11	0.19
24	Thiamine, mg	0.24	0.11				0.22	?			
25	Calcium, mg	1320	781	395	1350	1350	1240	800	?	1130	1130
26	Chlorine, mg	400	220	118	160	160	425	210	109	140	140
27	Cobalt[16]										
28	Copper, mg	0.26	0.22				0.28	0.20			
29	Fluorine[8]										
30	Iodine, mg	0.14	0.03		0.03	0.07	0.14	0.03		0.02	0.05
31	Iron[17], mg	2.5	2.2				3.5	1.7			
32	Magnesium, mg	64	29				60	?			
33	Manganese, mg	7.3				2.0	6.8	?			1.7
34	Phosphorus, mg	793	473	?	363	363	744	480	?	300	300
35	Potassium, mg	265	124				247	130			
36	Silicon										
37	Sodium, mg	264	144	78	102	102	280	130		90	90
38	Sulfur[18]										
39	Zinc										

/1/ Based on 3.3 gal per 100 chicks daily. /2/ Based on 4.7 gal per 100 chicks daily. /3/ Based on 4.8 gal per 100 hens daily. /4/ Kilocalories. These values represent the approximate amount of food energy actually available to and capable of use by the animal from the food absorbed. /5/ Crude. /6/ Based on 2.5% fat in ration of mash and scratch. /7/ 0.0006 mg β-carotene = one I. U. /8/ Presumably utilized but not required in diet. /9/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /10/ 0.025 µg crystalline D_3 (7-dehydrocholesterol) = one International Chick Unit. The chicken utilizes D_2 poorly. /11/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /12/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /13/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone), and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /14/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /15/ Includes pyridoxine, pyridoxal and pyridoxamine. /16/ Required only in form of cobalamin. /17/ 25 ppm of feed considered optimum. /18/ Required only in form of methionine or cystine.

46. DAILY NUTRIENT ALLOWANCES: TURKEY

Values are approximations to adequate requirements for normal growth, health and productivity. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species. For diets that supply these nutrient allowances, see table 50, Diets: Laboratory and Domestic Animals.

Specifications / Nutrients per kg body weight per day	Broad-breasted Bronze Turkeys		
	Young	Half-grown	Mature
	8-9 wk	16 wk	40-52 wk
	♂♀2 kg	♀4 kg; ♂6 kg	♀8 kg
	Growth		Breeding
(A)	(B)	(C)	(D)
1 Water			
2 Calories, metabolizable			
3 Total feed, g	75	52	32
4 Residue			
5 Protein[1], g	21	10.5	4.8
6 Carbohydrate			
7 Fat, g	2.1	2.0	1.3
8 "Essential" fatty acids			
9 Vitamin A, calc. as β-carotene[2], mg	0.24	0.17	0.10
10 Ascorbic acid			
11 Biotin			
12 Choline, mg	125		
13 Cobalamin[3]			
14 Vitamin D, calc. as cryst. D_3[4], µg	1.7	1.2	0.7
15 Vitamin E[5]			
16 Folic acid group[6], mg	0.07		0.2
17 Inositol			
18 Vitamin K[7]	0.10		
19 Niacin[8], mg	3.7		
20 Pantothenic acid, mg	0.83	0.62	0.42
21 Para-aminobenzoic acid			
22 Pyridoxine group[9], mg	0.26		
23 Riboflavine, mg	0.28	0.09	0.11
24 Thiamine			
25 Calcium, g	1.5	1.04	0.72
26 Chlorine[10,11] g	0.22	0.15	0.10
27 Cobalt			
28 Copper			
29 Fluorine			
30 Iodine, mg	0.06	0.06	0.03
31 Iron			
32 Magnesium			
33 Manganese, mg	4.1		1.1
34 Phosphorus[12], g	0.75	0.52	0.24
35 Potassium, g	0.10	0.10	0.05
36 Silicon			
37 Sodium[13], g	0.17	0.10	0.06
38 Sulfur			
39 Zinc			

/1/ Crude. /2/ 0.0006 mg β-carotene = one I. U. /3/ A generic term including cyancobalamin (vitamin B_{12}), and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /4/ 0.025 µg crystalline D_3 (7-dehydrocholesterol) = one I. U. /5/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /6/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /7/ The anti-hemorrhagic factor. A generic term for vitamin K_1 (2-methyl-3-phytyl-1,4-naphthoquinone), synthetic vitamin K (menadione = 2-methyl-1,4-naphthoquinone) and vitamin K_2 (2-methyl-3-difarnesyl-1,4-naphthoquinone). /8/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /9/ Includes pyridoxine, pyridoxal, and pyridoxamine. /10/ Represents chlorine added, as NaCl, to the diet, in addition to any Cl present in association with other nutrients. /11/ Chlorine, rather than sodium, may be the limiting factor in practical poultry feeds. /12/ At least two-fifths of this requirement should be supplied as inorganic PO_4. /13/ Represents sodium in added NaCl (cf Fn 10).

47. DAILY NUTRIENT ALLOWANCES: FISH

Values are approximations to adequate allowances, intended to provide a safe margin above minimum requirements where known. Presentation of values in terms of "per kg body weight per day" is for purposes of comparison of species, and does not necessarily imply a close correlation between nutrient need and body weight within the species.

Required (R); No demonstrated requirement (✗)

	Specifications / Nutrients per kg body weight per day	Trout[1]				Salmon[1,2]			
		Brook	Brown	Cutthroat	Rainbow	Chinook	Chum	Silver	Sockeye
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
1	Calories, metabolizable								
2	Total feed, g								
3	Residue								
4	Protein								
5	Carbohydrate[3], g	1.0-5.0	1.0-5.0	1.0-5.0	1.0-5.0	1.0-4.0		1.0-5.0	1.0-5.0
6	Fat								
7	"Essential" fatty acids								
8	Vitamin A	R?	R?	R?	R?	R?	R?	R?	R?
9	Ascorbic acid, mg	R?	R?	R?	20-40[4]	R?	R?	R?	R?
10	Biotin, µg	10-26	43-76	R?	15-26	R	R?	R?	R
11	Choline, mg	R?	R?	R?	4-8[4]	R?	R?	R?	R?
12	Cobalamin[5]	R?	R?	R?	R?	R	R?	R?	R
13	Vitamin D	R?	R?		R?				
14	Vitamin E	R?	R?	R?	✗	R?	R?	R?	R?
15	Folic acid group[6], mg	0.1-0.2	0.1-0.2	R?	0.1-0.2	R?			
16	Inositol, mg	R	R	R?	20-40[4]	R?			R?
17	Vitamin K								
18	Niacin[7], mg	3-4	3-4		3-4[8]	R?			R?
19	Pantothenic acid, mg	1-1.3	1-1.3	R?	1-1.3	R	R?	R	R
20	Para-aminobenzoic, mg				8-16[4]				
21	Pyridoxine group[9], mg	0.2-0.3	0.2-0.3	R?	0.2-0.3	R?			R?
22	Riboflavine, mg	0.4-0.7	0.4-0.7	R?	0.4-0.7	R?		R?	R?
23	Thiamine, mg	0.1-0.2	0.1-0.2	R	0.1-0.2	R	R?	R	R
24	Calcium								
25	Chlorine								
26	Cobalt								
27	Copper								
28	Fluorine								
29	Iodine	R	R	R?	R				
30	Iron								
31	Magnesium								
32	Manganese								
33	Phosphorus								
34	Potassium								
35	Silicon								
36	Sodium								
37	Sulfur								
38	Zinc								

/1/ Fresh water. /2/ Salt water. /3/ Recommended maximum levels to feed. /4/ Calc. from food intake per day and assumed average body weight of 4-months-old fingerling trout (McLaren et al '47). /5/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /6/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /7/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, anti-blacktongue factor. /8/ Only 0.08-0.4 mg according to McLaren et al '47. /9/ Includes pyridoxine, pyridoxal and pyridoxamine.

48. DIETS, LOW COST: MAN, U.S.A.

The table presents the percentage composition of a satisfactory "low cost" diet for persons of different ages, male and female, living within the area of the U.S.A. All values are based on total weight of food as purchased (fresh and canned fruits and vegetables, shell eggs, fluid milk, etc.). Values are not comparable to figures on a dry weight basis such as often used to define diets of other species. Ready availability throughout this area, costs, and the food habits of the population have been factors in determining the make-up of the food groups (columns E-O) and percentages allotted to each. The quantities in column C provide the nutrients prescribed in tables 31, 32, Daily Nutrient Allowances: Man.

	Age and Sex	Assumed Body Weight[1]	Total Food		Percentage Composition of Diet										
					Citrus Fruits, Tomatoes	Leafy, Green and Yellow Vegetables	Potatoes, Sweet-Potatoes	Other Vegetables and Fruits	Eggs[2]	Milk[3]	Meat, Poultry Fish	Dry Beans and Peas, Nuts	Flour[4], Cereals	Fats[5] and Oils	Sugar, Syrups, Preserves
		kg	g/kg/da	kg/pers/wk	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
	Children through 12 yr														
1	9-12 mo	10.0	122[6]	8.6	9.3	7.9	2.6	5.3	2.6	66	1.3	0.3	3.3	0.3	0.3
2	1-3 yr	13.4	95	8.9	8.9	8.9	5.1	5.1	2.5	64	2.5	0.3	7.4	0.6	0.6
3	4-6 yr	19.6	72	9.9	8.0	8.0	6.9	5.7	2.3	52	4.6	0.6	8.0	1.7	1.7
4	7-9 yr	27.9	58	11.3	8.0	8.0	10.0	6.0	2.0	46	6.0	1.1	9.0	2.0	2.5
5	10-12 yr	38.0	50	13.2	7.7	7.7	10.3	6.0	1.7	39	6.0	0.8	11.2	2.6	2.6
	Girls														
6	13-15 yr	50.7	40	14.0	7.3	7.3	10.5	5.7	1.6	44	6.4	0.8	11.3	2.4	2.4
7	16-20 yr	57.4	30	12.2	8.4	8.4	11.2	6.5	1.8	38	7.4	0.9	12.0	2.9	2.3
	Boys														
8	13-15 yr	49.3	45	15.6	7.3	7.3	11.7	6.6	1.4	40	5.8	1.4	13.1	2.9	2.5
9	16-20 yr	66.1	37	17.0	6.7	7.3	13.3	6.7	1.3	36	5.3	1.3	15.3	3.7	2.7
	Women														
10	Sedentary	56.0	28	11.1	8.1	9.2	9.2	7.2	2.0	42	8.1	1.0	8.1	2.6	2.6
11	Moderately active	56.0	30	11.7	7.7	8.7	11.6	6.8	1.9	40	7.7	1.0	8.7	2.9	2.9
12	Very active	56.0	35	13.8	8.2	8.2	13.2	6.6	1.6	34	6.6	1.2	14.0	3.3	3.3
13	Pregnant	56.0	38	14.9	7.6	9.1	7.6	6.1	2.1	49	6.9	0.8	7.6	1.9	1.5
14	Nursing	56.0	51	19.9	8.5	8.0	9.1	5.1	1.6	52	5.7	0.6	6.8	1.4	1.1
15	60 years or over[7]	56.0	30	11.3	9.0	10.0	10.0	7.0	1.6	41	8.0	0.5	9.0	2.0	2.0
	Men														
16	Sedentary	70.0	24	11.6	7.8	8.8	6.9	6.9	1.9	40	7.8	1.0	12.7	2.9	2.9
17	Physically active	70.0	28	13.8	8.2	8.2	13.2	6.6	1.6	34	6.6	1.2	14.0	3.3	3.3
18	With heavy work	70.0	35	17.0	6.7	6.7	16.0	6.7	1.3	27	5.3	1.7	20.7	5.0	2.7
19	60 years or over[7]	65.0	27	12.3	8.3	9.3	12.0	6.5	1.5	38	7.4	0.5	12.0	2.3	2.3

/1/ These weights are average for North American whites. Values for children are for the mid-age in the ranges given. Where sex is not specified and a weight difference exists, the weight for males has been presented. /2/ One medium egg weighs approximately 54 grams. /3/ Milk requirements for children can be replaced by equivalent quantities of evaporated milk (74% water) or dry milk (3-4% water) or its equivalent (on a protein and calcium basis, not moisture) in evaporated milk, dry milk, cheese or ice cream./4/ 1.5 grams of bread may be considered the equivalent of 1 gram of flour. The foods in this group should be supplied frequently in the form of wholegrain,enriched, or restored products. /5/ For small children and pregnant and nursing women, cod-liver oil or some other source of vitamin D is also needed. For elderly persons and for those who have no opportunity for exposure to clear sunshine, a small amount of vitamin D is also desirable. /6/ Value high because the total intake of infants is chiefly milk and has, therefore, an unusually high water content (cf Fn 3). /7/ Sedentary.

49. DIETS, MODERATE COST: MAN, U.S.A.

The table presents the percentage composition of a satisfactory "moderate cost" diet for persons of different ages, male and female, living within the area of the U. S. A. Ready availability throughout this area, costs, and the food habits of the population have been factors in determining the make-up of the food groups (columns E-O) and the percentages allotted to each. The quantities in Column C provide the nutrients prescribed in tables 31, 32, Daily Nutrient Allowances: Man.

	Age and Sex	Assumed Body Weight[1]	Total Food		Percentage Composition of Diet											
					Citrus Fruits, Tomatoes	Leafy, Green and Yellow Vegetables	Potatoes, Sweet-Potatoes	Other Vegetables and Fruits	Eggs[2]	Milk[3]	Meat, Poultry, Fish	Dry Beans and Peas, Nuts	Flour[4], Cereals	Fats[5] and Oils	Sugar, Syrups, Preserves
		kg	g/kg/da	kg/pers/wk	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
	Children through 12 yr														
1	9-12 mo	10.0	122[6]	8.6	9.3	7.9	2.6	5.3	2.6	66	1.3	0.3	3.3	0.3	0.3
2	1-3 yr	13.4	105	9.8	9.2	9.2	2.3	8.1	2.5	58	3.4	0.3	5.7	0.5	0.5
3	4-6 yr	19.6	82	11.2	9.1	9.1	4.1	9.1	2.8	51	5.0	0.3	6.1	1.5	2.0
4	7-9 yr	27.9	67	13.0	8.7	8.7	6.1	8.7	2.4	48	6.1	0.4	6.9	1.7	2.6
5	10-12 yr	38.0	56	14.8	8.4	9.2	6.9	7.7	2.1	45	6.9	0.4	8.4	2.3	2.7
	Girls														
6	13-15 yr	50.7	45	15.9	7.8	10.0	7.1	10.0	2.0	42	7.8	0.3	7.8	2.5	2.5
7	16-20 yr	57.4	37	14.7	8.4	10.8	7.7	10.8	2.1	39	8.4	0.4	7.7	2.3	2.7
	Boys														
8	13-15 yr	49.3	51	17.7	7.7	9.0	10.3	9.0	1.8	38	7.7	0.6	10.3	2.9	2.9
9	16-20 yr	66.1	42	19.3	8.3	9.4	10.6	8.3	1.6	35	7.7	0.9	12.4	3.2	2.9
	Women														
10	Sedentary	56.0	32	12.5	9.1	11.8	6.4	11.8	2.5	38	9.1	0.2	6.4	2.3	2.7
11	Moderately active	56.0	35	13.7	8.3	11.6	8.3	11.6	2.3	34	9.1	0.4	8.3	2.9	2.9
12	Very active	56.0	40	15.6	8.7	10.9	9.5	11.7	2.0	30	8.7	0.7	10.9	3.3	3.3
13	Pregnant	56.0	42	16.3	9.8	11.1	6.3	8.3	1.9	44	8.3	0.3	6.3	1.7	1.7
14	Nursing	56.0	52	20.4	10.0	8.9	6.7	7.8	1.5	49	6.7	0.3	5.6	1.7	1.7
15	60 yr or over[7]	56.0	33	13.0	9.5	12.2	6.9	10.4	2.1	40	8.7	0.2	6.1	1.7	2.2
	Men														
16	Sedentary	70.0	28	13.7	8.3	11.6	8.3	11.6	2.3	34	9.1	0.4	8.3	2.9	2.9
17	Physically active	70.0	32	15.6	8.7	10.9	9.5	11.7	2.0	30	8.7	0.7	10.9	3.3	3.3
18	With heavy work	70.0	39	19.0	8.4	9.5	11.9	10.1	1.7	25	8.4	0.9	16.7	4.8	3.0
19	60 yr or over[7]	65.0	32	14.5	8.6	10.9	8.6	9.4	1.9	39	8.6	0.4	7.8	2.3	2.3

/1/ These weights are average for North American whites. Values for children are for the mid-age in the ranges given. Where sex is not specified and a weight difference exists, the weight for males has been presented. /2/ One medium egg weighs approximately 54 grams. /3/ It should be noted that milk contains about 87% water. Milk requirements can be replaced by equivalent quantities of cheese (Cheddar cheese, 40% water; cottage cheese, 75% water) or evaporated milk, 74% water; or dry milk 3-4% water. /4/ 1.5 grams of bread may be considered the equivalent of 1 gram of flour. The foods in this group should be supplied frequently in the form of wholegrain, enriched, or restored products. /5/ For small children and pregnant and nursing women. cod-liver oil or some other source of vitamin D is also needed. For elderly persons and for those who have no opportunity for exposure to clear sunshine, a small amount of vitamin D is also desirable. /6/ Value high because the total food intake of infants is chiefly milk and therefore contains a high proportion of water (cf Fn 3). /7/ Sedentary.

50. DIETS: LABORATORY AND DOMESTIC ANIMALS

Diets have been selected from a large number of possible diets. They are not necessarily optimal, nor do they suit all important conditions and feeding purposes. Consult texts on feeding (see biblio.) for more detailed information. Unless otherwise indicated, values in col. E are grams/100 g (or lb/100 lb) of ration.

Species	Age	Body Weight	Daily Food Intake[1]	Diet
	mo	kg	g/kg body wt	g/100 g
(A)	(B)	(C)	(D)	(E)
Cattle, Beef				
Normal growth		227	28	Alfalfa hay, 71; barley, 14.3; corn, yellow, 14.3.
Fattening calf		272	I-38 II-38 III-27	Diet I: Alfalfa hay, 13.2; corn silage, 43; corn, 39; cottonseed meal, 4.3. Diet II: Prairie hay, 13.1; corn silage, 44; corn, 36; cottonseed meal, 7.4; $CaCO_3$, 0.2. Diet III: Vetch and oat hay, 36; beet pulp, molasses, 24.3; barley, 36; cottonseed meal, 3.1.
Yearling steer		363	23	Oat hay, moderately green, 25; alfalfa hay, 10; barley, 30; beet pulp, molasses dried, 20; molasses, cane, 10; cottonseed meal (41% protein), 5.
Wintering pregnant cow		408	I-23 II-22 III-44	Diet I: Alfalfa hay, 19.8; oat hay, 80. Diet II: Corn fodder, 49; barley straw, 25; alfalfa hay, 25. Diet III: Corn silage, 69; oat straw, 27; cottonseed meal (41% protein), 4.1.
Cattle, Dairy				
Calf		45	120	Whole milk, 100.
Heifer		272	I-25 II-31 III-25 IV-46	Diet I: Mixed legume-grass hay, 66; oats (corn or barley), 34. Diet II: Alfalfa hay, 100. Diet III: Timothy hay, 66; barley, 33; limestone, 0.4. Diet IV: Alfalfa hay, 40; corn silage, 60.
Mature lactating cow		635	I-30 II-33 III-53	Diet I: Alfalfa, 75; barley, 25. Diet II: Timothy hay, 19.1; corn silage, 58; corn and cob meal, 16.3; soybean meal, 6.8; limestone, 0.3. Diet III: Alfalfa hay, 29; corn silage, 70.7; steamed bone meal, 0.3.
Chicken, Germ-free				
♂♀Bantam	1	0.11	140	Casein, 25; gelatin, 10; L-cystine, 0.2; corn oil, 6; corn starch, 45; lactose, 4; whole liver powder (pork), 2; yeast extract, 2; vitamin A esters, 400 I. U.; ascorbic acid, 0.2; vitamin D_3, 50 A. O. A. C. units; tocopherol, 0.025; 2-methyl-1,4-naphthoquinone, 0.005; thiamine Cl.HCl, 0.006; riboflavine, 0.003; calcium pantothenate, 0.02; nicotinamide, 0.05; choline Cl, 0.2; pyridoxine Cl, 0.002, i-inositol, 0.1; biotin, 0.00001; folic acid, 0.001; $CaCO_3$, 1.5; $CaHPO_4$, 0.28; K_2HPO_4, 1; NaCl, 0.25; KI, 3.18; $MgSO_4.7H_2O$, 0.07; $FeC_6H_5O_7$, 0.38; $CuSO_4.5H_2O$, 0.02; $CaCl_2.6H_2O$, 0.025; $ZnSO_4.7H_2O$, 0.005; $Na_2B_4O_7.10H_2O$, 0.025; $AlK(SO_4)_2.12H_2O$, 0.004.
♂♀White Leghorn	1	0.22	80	Same diet as bantam.
Chicken, Rhode Island Red				
♂♀Young	0.7	0.23	140	Corn, ground yellow, 49; standard wheat middlings, 10; alfalfa meal (75,000 or more I. U. of vitamin A per lb), 5; soybean oil meal, 20; fish meal, 4; meat meal, 4; steamed bone meal, 1; ground limestone, 1; dried whey, 5; salt, 0.5; vitamin A and D feeding oil, 0.1 (oil contains 300 International Chick Units vitamin D, 1500 I. U. vitamin A per gram); plus anhydrous $MnSO_4$, 0.0125 g per 100 g feed.

/1/ The numerals I, II, III, IV occurring occasionally in column D, refer to alternative dietary mixtures whose compositions are given in column E.

50. DIETS: LABORATORY AND DOMESTIC ANIMALS (Continued)

Diets have been selected from a large number of possible diets. They are not necessarily optimal, nor do they suit all important conditions and feeding purposes. Consult texts on feeding (see biblio.) for more detailed information. Unless otherwise indicated, values in col. E are grams/100 g (or lb/100 lb) of ration.

Species	Age	Body Weight	Daily Food Intake[1]	Diet
	mo	kg	g/kg body wt	g/100 g
(A)	(B)	(C)	(D)	(E)
Chicken, Rhode Island Red (concluded)				
♂♀Half-grown	2.1	1.25	67	Corn, ground yellow, 47; standard wheat middlings, 15; wheat bran, 10; alfalfa meal, 5 (meal contains 75,000 or more I. U. of vitamin A per lb); soybean oil meal, 17; dried whey, 2; steamed bone meal, 2.5; ground limestone, 1; salt, 0.5; vitamin A and D feeding oil[2], 0.1; plus anhydrous $MnSO_4$, 0.0125 g per 100 g feed.
♀Mature, breeding	7.2-10.4	2.5	45	Corn, ground yellow, 49; standard wheat middlings, 15; wheat bran, 10; alfalfa meal, 5 (meal contains 75,000 or more I. U. of vitamin A per lb); soybean oil meal, 4; fish meal, 4; meat meal, 4; dried whey, 4; steamed bone meal, 1; ground limestone, 3.5; salt, 0.5; vitamin A and D feeding oil[2], 0.3; plus anhydrous $MnSO_4$, 0.0125 g per 100 g feed.
Dog				
Young		4.5	53	Meat, meat by-products including bone, or fish, 20; soybean meal, wheat germ, corn germ, or nut meal, 20; corn, wheat, or barley, 50; carrots, beet by-products, or tomato by-products, 2-5; iodized salt, 0.24-0.5; milk, liver meals, or fermentation solubles, q.s.; fish liver oils and irradiated yeast, q.s.
Adult		13.6	I-22 II-22?	Diet I: Same as foregoing diet for young dog. Diet II (a basic purified diet): Casein, vitamin-free, 10; dextrose, 15; dextrin, 8; lard, 6; salt mixture, Wesson '32, 0.8 (composed of: NaCl, 10.5; KCl, 12; KH_2PO_4, 31; $Ca_3(PO_4)_2$, 14.9; $CaCO_3$, 21; $MgSO_4$, 9; $FePO_4.4H_2O$, 1.47; $MnSO_4$, 0.02; $K_2Al_2(SO_4)_4.24H_2O$, 0.009; $CuSO_4.5H_2O$, 0.039; NaF, 0.057, KI, 0.005); agar, 1.2; distilled water, 58. To each 1000 g of dry ingrediants, add thiamine, 2.0 mg; riboflavine, 1.6 mg; nicotinic acid, 16.0 mg; calcium pantothenate, 13.0 mg; pyridoxine, 1.0 mg; choline, 1 g; 2-methyl-naphthoquinone (vitamin K), 0.6 μg; alpha tocopherol (vitamin E), 33 mg; biotin, 0.6 mg; folic acid, 0.6 mg; vitamin A, 30 g; vitamin D, 5 g; vitamin B_{12}, 1 mg.
Fish				
Fish, trout, brook, brown, and rainbow	0.0-3	0.0001-0.002	80-100 at 10° C[3]	Diet I[4]: Beef liver, 49; pork spleen, 49; salt, 2. Diet II[4]: Beef liver, 100. Diet III[4]: Beef liver, 60; horse meat, 40.
	3-9	0.002-0.05	20-60 at 10° C[3]	Diet I[4]: Pork or beef spleen 35; beef liver, 15; salt, 2; fish meal, 12; wheat middlings, 12; dried skim milk or distillers solubles, 12; cottonseed meal, 12. Diet II[4]: Beef liver, 33; beef spleen, 33; horse meat, 34. Diet III[4]: Cooked carp or other rough fish, 45; oatmeal, 5; beef liver, 15; beef or pork spleen, 35.
	4	0.004	60 at 10° C[3]	Diet I: Casein, 55; gelatin 15; crisco or lard, 9; potato starch (cooked), 8; cellu flour, 9; minerals, 4 (composed of U.S.P. XII salt mixture No. 2: sodium chloride, 1.73 g; magnesium sulfate, 5.45 g; sodium biphosphate, 3.47 g; potassium phosphate, 9.54 g; calcium biphosphate, 5.4 g; ferric citrate, 1.18 g; calcium lactate, 13 g to which the following trace ele-

/1/ The numerals I, II, III, IV occurring occasionally in column D, refer to alternative dietary mixtures whose compositions are given in column E. /2/ See item 45, column E for composition. /3/ Food allowance for trout is in proportion to body size and water temperature (the larger the fish, the smaller allowance in proportion to body weight and the higher the temperature, within limits, the greater the allowance). /4/ Hatchery rearing diet.

50. DIETS: LABORATORY AND DOMESTIC ANIMALS (Continued)

Diets have been selected from a large number of possible diets. They are not necessarily optimal, nor do they suit all important conditions and feeding purposes. Consult texts on feeding (see biblio.) for more detailed information. Unless otherwise indicated, values in col. E are grams/100 g (or lb/100 lb) of ration.

Species	Age	Body Weight	Daily Food Intake[1]	Diet
	mo	kg	g/kg body wt	g/100 g
(A)	(B)	(C)	(D)	(E)
Fish (concluded)				
Fish, trout, brook, brown, and rainbow (concluded)	4	0.004	60 at 10° C[3]	ments have been added per 100 g: aluminum chloride, 18 mg; zinc sulfate, 357 mg; copper gluconate, 511 mg; manganous sulfate, 80 mg; potassium iodide, 17 mg; cobalt chloride, 105 mg); vitamin supplement (composed of the following per 100 g: thiamine, 6 mg; riboflavine, 20 mg; pyridoxine, 4 mg; choline, 800 mg; para-aminobenzoic acid, 40 mg; niacin, 80 mg; calcium pantothenate, 28 mg; inositol, 400 mg; biotin, 0.6 mg; folic acid, 1.5 mg; B_{12}, 9 µg; alpha tocopherol, 40 mg; vitamin K, 4 mg; vitamin C, 200 mg; vitamin A and D, cod-liver oil to replace same amount of fat in original formula, 2ml); water added at the rate of 300 g per 100 g dry ingredients.
Horse				
Maintenance		544	16	Oat or barley, 100.
Medium work		544	19	Timothy hay, 65; oats, 13; corn, 21.8.
Pregnant mare		544	18	Alfalfa hay, 18.9; prairie hay, 43; oats, 38.
Lactating mare		544	21	Timothy hay, 32; alfalfa hay, 28; oats, 40.
Growing colt		272	23	Timothy hay, 42; alfalfa hay, 14.3; oats, 22; corn, 14.3; wheat bran, 7.1.
Monkey, Rhesus Juvenile				
Mature		1.5-3	40	Sucrose, 71; "de-vitaminized" casein, 18; corn oil, 4; salt mixture, 3 (composed of $CaCO_3$, 300 g; K_2HPO_4, 470 g; $CaHPO_4$, 680 g; $MgSO_4$, 100 g; NaCl, 670 g; KCl, 115 g; $FeC_6H_5O_7$, 55 g; KI, 1.6 g; $MnSO_4.H_2O$, 9 g; $ZnCl_2$, 4 g; $CuSO_4$, 2.4 g; $CoCl_2$, 0.2 g); whole liver substance, 2; 1.2 liver concentrate powder, 2. To each 18 g of casein add: thiamine hydrochloride, 350 µg; pyridoxine hydrochloride, 350 µg; nicotinamide, 2.5 mg; choline chloride, 100 mg; inositol, 100 mg; para-aminobenzoic acid, 30 mg; calcium pantothenate, 2 mg; riboflavine, 350 µg; folacin, 200 µg; biotin, 20 µg; ascorbic acid, 10 mg. To each 4 g of corn oil add: 90% β-carotene, 90 µg; calciferol, 0.8 µg; α-tocopherol, 5 mg; menadione, 100 µg.
Rabbit, New Zealand White				
Mature		5	68	Casein, 20; dextrin, 35; cellulose, 15; soybean meal, 10; salt mixture, 4 (composed of 2.5% $MnSO_4.4H_2O$ and 97.5% of the Hubbel, Mendel, and Wakeman mixture, which is made up of the following minerals, g per 4 g mixture: Ca, 0.87; Mg, 0.418; Na, 0.11; K, 0.578; P, 0.204; S, 0.018; Fe, 0.02; I, 0.0002; Mn, 0.005; F, 0.0018; Al, 0.000038; Cu, 0.0014; Cl, 0.28); yeast, 15; A-D mixture[5], 1.
Rat				
Cotton	6	0.18	72.2	Kale, 4.8; apple, 11.9; rat laboratory chow, 48; rabbit pellets, 29; carrots, 4.8; peanut butter, 2.0.

/1/ The numerals I, II, III, IV occurring occasionally in column D, refer to alternative dietary mixtures whose compositions are given in column E. /3/ Food allowance for trout is in proportion to body size and water temperature (the larger the fish, the smaller allowance in proportion to body weight and the higher the temperature, within limits, the greater the allowance). /5/ 1200 I. U. vitamin A and 170 I. U. vitamin D.

50. DIETS: LABORATORY AND DOMESTIC ANIMALS (Continued)

Diets have been selected from a large number of possible diets. They are not necessarily optimal, nor do they suit all important conditions and feeding purposes. Consult texts on feeding (see biblio.) for more detailed information. Unless otherwise indicated, values in col. E are grams/100 g (or lb/100 lb) of ration.

Species	Age	Body Weight	Daily Food Intake[1]	Diet
	mo	kg	g/kg body wt	g/100 g
(A)	(B)	(C)	(D)	(E)
Rat (concluded)				
White	1-6	0.18	38	Casein, 35; corn starch, 37; lard, 15; butter fat, 9; No. 4 salt mixture, 4 (composed of $CaCO_3$, 134.8 g; Na_2CO_3, 34.2 g; $MgCO_3$, 24.2 g; K_2CO_3, 141.3 g; H_3PO_4, 103.2 g; HCl, 53 g; H_2SO_4, 9.2 g; citric acid H_2O, 111 g; Fe citrate H_2Ox, 6.3 g; KI, 0.02 g; $MnSO_4$, 0.079 g; NaF, 0.248 g; $K_2Al_2(SO_4)_4$, 0.0245 g). To induce rapid growth of 4 or more grams per day, 0.2-0.6 g of yeast and 20-30 g of fresh lettuce added daily.
Sheep				
Bred ewes, first 100 days of gestation		45	I-33 II-35 III-60	Diet I: Red clover hay, 45; timothy hay, 55. Diet II: Prairie hay, 57; alfalfa hay, 43, Diet III: Soybean hay, 34; corn silage, 66.
Ewes in lactation		49 54 64	I-66 II-51 III-50	Diet I: Corn silage, 55; alfalfa hay, 28; linseed meal, 2.8; barley, 13.8. Diet II: Corn silage, 33; linseed meal, 1.6; timothy hay, 24.5; alfalfa hay, 30; barley, 11.5. Diet III: Alfalfa hay, 44; corn silage, 35; barley, 21.
Fattening lambs		32	I-120 II-37 III-48	Diet I: Barley (corn, oats, or sorghum), 9.4; beet pulp, wet, 71; alfalfa hay, 20.1. Diet II: Corn (barley or sorghum), 42; alfalfa, 58. Diet III: Corn, 32; soybean oil meal, 5.9; alfalfa hay, 32; corn silage, 30.
Swine				
Swine		45	I-53 II-53 III-53 IV-53	Diet I[6]: Corn, 63; oats, 15; soybean meal, 7.8; middlings, 5; alfalfa meal, 5; limestone, 0.7; salt, 0.5. Diet II[6]: Barley, 50; oats, 40; linseed meal, 3; fish meal, 1; meat meal, 3.0; minerals, 3[7]; A and D oil (99.3 I.U. vitamin A and 19.8 I.U. vitamin D/100 g of diet). Diet III[6]: Soybean meal, 8; alfalfa meal, 4.5; barley, 83; tankage, 3; bonemeal, 0.5; limestone, 0.5; salt (NaCl), 0.5. Diet IV[6]: Corn, 82; soybean meal, 6.5; meat and bone scrap, 2.5; fish meal, 2.5; cottonseed meal, 2.5; alfalfa meal, 2.5; limestone, 0.5; bonemeal, 0.5; salt (NaCl), 0.5.
Turkey, Broad-breasted Bronze				
♂♀Young	1.8-2.1	2	75	Corn, ground yellow, 25; standard wheat middlings, 10; alfalfa meal, 5 (meal contains 75,000 or more I. U. of vitamin A per pound); soybean oil meal, 35; fish meal 6; meat meal, 6; steamed bone meal, 2; ground limestone, 2; salt, 0.5; dried whey, 8; vitamin A and D feeding oil, 0.5 (oil contains 300 International Chick Units vitamin D, 1500 I. U. vitamin A per gram); plus anhydrous $MnSO_4$, 0.0125 g per 100 g feed.
♂Half-grown	3.2	6	52	Corn, ground yellow, 35; pulverized oats, 20; alfalfa meal, 4 (meal contains 75,000 I. U. vitamin A per pound); soybean oil meal, 23; fish meal, 4; meat meal, 4; steamed bone meal, 2.5; ground limestone, 1.5; salt, 0.5; dried whey, 6; vitamin A and D feeding oil, 0.5; (oil contains 300 International Chick Units vitamin D, 1500 I. U. vitamin A per gram); plus anhydrous $MnSO_4$, 0.0125 g per 100 g of feed.

/1/ The numerals I, II, III, IV occurring occasionally in column D, refer to alternative dietary mixtures whose compositions are given in column E. /6/ An antibiotic-vitamin B_{12} supplement is recommended for addition to all diets not otherwise provided with an antibiotic and vitamin B_{12}, at a level suited to its type. /7/ Iodized salt (NaCl), 20%; steamed bonemeal, 37.7%; ground limestone, 40%; ferrous sulfate, 2%; manganese sulfate, 0.2%; copper sulfate, 0.1%.

50. DIETS: LABORATORY AND DOMESTIC ANIMALS (Concluded)

Diets have been selected from a large number of possible diets. They are not necessarily optimal, nor do they suit all important conditions and feeding purposes. Consult texts on feeding (see biblio.) for more detailed information. Unless otherwise indicated, values in col. E are grams/100 g (or lb/100 lb) of ration.

	Species	Age	Body Weight	Daily Food Intake[1]	Diet
		mo	kg	g/kg body wt	g/100 g
	(A)	(B)	(C)	(D)	(E)
	Turkey, Broad-breasted Bronze (concluded)				
195	♀Half-grown	3.2	4	52	Corn, ground yellow, 35; pulverized oats, 20; alfalfa meal, 4 (meal contains 75,000 I. U. vitamin A per pound); soybean oil meal, 23; fish meal, 4; meat meal, 4; steamed bone meal, 2.5; ground limestone, 1.5; salt, 0.5; dried whey, 6; vitamin A and D feeding oil, 0.5 (oil contains 300 International Chick Units vitamin D, 1500 I. U. vitamin A per gram); plus anhydrous $MnSO_4$, 0.0125 g per 100 g of feed.
200	♀Mature	8-12	8	32	Corn, ground yellow, 31; standard wheat middlings, 20; pulverized oats, 20; alfalfa meal, 7 (meal contains 75,000 or more I. U. of vitamin A per pound); wheat bran, 4.5; dried whey, 3; fish meal, 5; meat meal, 5; ground limestone, 4; salt, 0.5; vitamin A and D feeding oil, 0.5 (oil contains 300 International Chick Units vitamin D, 1500 I. U. vitamin A per gram); crystalline riboflavine, 0.2 mg per 100 g of feed; plus anhydrous $MnSO_4$, 0.0125 g per 100 g of feed.
205					

/1/ The numerals I, II, III, IV occurring occasionally in column D, refer to alternative dietary mixtures whose compositions are given in column E.

51. ZOO DIETS: MAMMALS, CARNIVORES

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks. Differences in diet reflect climatic conditions, food availability, and individual variation within species. Body weights are only estimated and the amounts of food eaten are approximate only, and are for a single specimen of the species listed.

	Species	Sex	Body Weight	Total Feed per Week	Feed/kg Body Weight per Day	Composition of Diet		
						Horse Meat	Horse Liver	Horse Kidney
			kg	kg	g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	CARNIVORA							
1	Badger, Canadian (Taxidea taxus taxus)		14	3	31			
2	Bear, Eurasian, brown (Ursus arctos arctos)	M	205	43	30	33		
3	Bear, grizzly (U. horribilis horribilis)	M	318	54	24	27		
4	Bear, kodiak (U. middendorfii)	M	364	60	24	32		
5	Bear, Malayan sun-bear (Helarctos malayanus)	F	23	7	44	31		
6	Bear, polar (Thalarctos maritimus)	M	341	60	25	23		
7	Bear, polar (T. maritimus)	M	386	83	31			
8	Bear, polar (T. maritimus)	F	136	50	53	22		
9	Bear, spectacled (Tremarctos ornatus)	M	114	41[8]	51			
10	Cat, jungle (Felis chaus fulvidina)	F	4	3	107	83	17[10]	
11	Cheetah (Acinonyx jubatus)	M	55	18	47	92	3[10]	
12	Dingo (Canis dingo)[11]	M	23	11	68	10	4[10]	
13	Hyena, spotted (Crocuta crocuta)	M	45	8	25	83	6[10]	
14	Jaguar (Panthera onca)	M	80	18	32	86	5	8
15	Jaguar (P. onca)	M	80	15	27	91	3[10]	
16	Jaguar (P. onca)	F	64	15	33	84	6	9
17	Leopard, black (P. pardus)	M	45	13	41	88	4	7
18	Lion (P. leo)	M	159	27	24	95	3	
19	Lynx, Yukon (Felis canadensis mollipilosus)		16	8	71	70		
20	Ocelot (F. pardalis)		7	5	100	83	17	
21	Panda, lesser (Ailurus fulgens fulgens)		6	9	214			
22	Raccoon (Procyon lotor)		5	3	86	15		
23	Tiger, Bengal (Panthera tigris)	M	227	45	28	97	2	
24	Tiger, Bengal (P. tigris)	F	136	32	34	96	3	
25	Wolf, maned (Chrysocyon jubatus)	M	27	12	63		4[10]	
26	Wolf, North American (Canis lupus nubilis)	M	36	15	60	15	3[10]	
	PINNIPEDIA							
27	Sea-lion, (Zalophus californianus)	M	273	6	3			
28	Seal, harbor (Phoca vitulina geronimensis)	F	32	13	58			

/1/ Composed of: meat 56%, kibbled dog biscuit 14%, powdered milk 3%, bone meal 3%, sodium chloride 1%, and water 23%. /2/ S. D. = San Diego Zoological Gardens, San Diego, California. N. Y. = New York Zoological Park, New York, N. Y. Chi. = Lincoln Park Zoo, Chicago, Ill. /3/ Eggs 2%, bran and honey mix 3%. /4/ Eggs 3%, and bran and honey mix 7%. /5/ Eggs 14%, and bran and honey mix 20%. /6/ During summer total bread allowance increased 2-4 times. /7/ Eggs 3%, and bran and honey mix 8%. /8/ Includes 3

51. ZOO DIETS: MAMMALS, CARNIVORES (Concluded)

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks. Differences in diet reflect climatic conditions, food availability, and individual variation within species. Body weights are only estimated and the amounts of food eaten are approximate only, and are for a single specimen of the species listed.

Composition of Diet (concluded)												
Bone Meal	Dog Food Mix[1]	Fowl	Bread	Milk	Butter-fish	Mackerel	Fish, General	Vege-tables	Apples	Fruit, General	Misc.	Zoo[2]
g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	
(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)
	100											SD
			13			20		23	2	4	5[3]	SD
			14			14		27	3	5	10[4]	SD
			9		23	23			14			NY
								15	10	10	34[5]	SD
			9[6]		46	23						NY
	15		34				46	5				Chi.
			8					36	7	16	11[7]	SD
			40						33		27[9]	NY
												SD
		5										SD
	43	8		29							6[12]	SD
-		11										SD
1												NY
		6										SD
1												NY
1												NY
1												NY
				26							4[12]	SD
												SD
				18					9	64[13]	9[14]	SD
	45		10				30					Chi.
1												NY
1												NY
	89	7										SD
	76	6										SD
					50	25	25[15]					NY
							100					NY

gallons of milk (1.8 kg powdered milk to 11 liters water); conversion of gallons of milk to kilograms made on assumption that 1 liter milk = 1 kg. /9/ Milk (see Fn 8). /10/ Combination of horse liver and kidney. /11/ Immature animal. /12/ Eggs. /13/ Includes bananas 36%, grapes 9%, dates 9%, and raisins 2%. /14/ Eggs 8%, Pablum 1%. /15/ Smelts.

52. ZOO DIETS: MAMMALS, HERBIVORES

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks. Differences in diet reflect climatic conditions, food availability, and individual variation within species. Body weights are only estimated and the amounts of food eaten are approximate only, and are for a single specimen of the species listed.

	Species	Sex	Body Weight	Total Feed per Week	Feed/kg Body Weight per Day	Composition of Diet				
						Alfalfa	Browse	Clover	Oat Hay	Timothy
			kg	kg	g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	PRIMATES									
1	Ape, celebes, crested (Macaca niger)	M	23	14	87					
2	Chimpanzee (Pan troglodytes)	M	61	30	70					
3	Colobus, East African (Colobus polykomos kikuyensis)	M	18	14	111					
4	Gorilla (Gorilla gorilla)	F	135	25[7]	27					
5	Gorilla (G. gorilla)	F	32	29[9]	128					
6	Gorilla (G. gorilla)	M	250	87	50					
7	Gibbon (Hylobates lar)	F	9	6	95					
8	Guenon, beira (Cercopithecus mitis erythrarchus)	M	1	8	1143					
9	Macaque, Burmese, pig-tailed (Macaca nemestrina andamensis)	F	2	10	715					
10	Macaque, Formosan, rock (M.cyclopis)	M	1	9	280					
11	Macaque, stump-tailed (M. speciosa)	M	25	16	92					
12	Marmoset, red-handed (Mystax midas)	F	0.4	2	715					
13	Monkey, mantled, howling (Alouatta palliata aequatorialis)	M	3	5	238			2		
14	Orangutan (Pongo pygmaeus)	M	48	15[20]	45					
15	Orangutan (P. pygmaeus)	M	68	27	57					
16	Saki, golden headed (Pithecia pithecia chrysocephala)	M	1	6	857					
	ARTIODACTYLA									
17	Alpaca (Lama pacos)[24]	M	91	20	31	28[25]	16			
18	Anoa (Anoa depressicornis)[24]	M	102	36	50	40[25]	13		17	
19	Anoa (A. depressicornis)	F	102	37	52			60	9	
20	Antelope, sable (Hippotragus niger roosevelti)[24]	M	250	59	34	32[25]	46			
21	Aoudad (Amnotragus lervia)	M	55	18	47	46[25]	13			
22	Bison (Bison bison bison)	M	273	139	73		6		92	
23	Blackbuck (Antilope cervicapra)[24]	M	45	13	41	43[25]	18			
24	Bongo, eastern (Boocercus eurycerus isaaci)	F	220	58	38			65		
25	Buffalo, African (Syncerus caffer)[24]	M	1636	160	14	85[25]	7			
26	Camel, Bactrian (Camelus bactrianus)[24]	M	841	168	29	57[25]	8			

/1/ Grain mix feed composed of: beet pulp 30%, rolled barley 32%, bran 11%, rolled oats 8%, ground corn 11%, linseed meal 4%, bone meal 1%, and salts 1%. /2/ S.D. = San Diego Zoological Gardens, San Diego, California. N. Y. = New York Zoological Park, New York, N. Y. Chi. = Lincoln Park Zoo, Chicago, Ill. /3/ Sweet. /4/ Other fruits 31%, and other vegetables 31%. /5/ Other fruits 14%, other vegetables 20%, rice 5%, and milk 3%. /6/ Other fruits 25%, other vegetables 18%, corn 2%, wheat 1%, and rice 1%. /7/ Oranges 5%, and other vegetables 12%. /8/ Plus tablespoon of cod liver oil and 12 drops of vitamin formula per day. /9/ Plus tablespoon of Vi-Magna per day. /10/ Other fruits 26%, milk 23%, and Pablum 2%. /11/ Sweet 8%, and Irish 8%. /12/ Milk and cream 28%, grapes 25%, and other fruits 2%. /13/ Other fruits 14%, other vegetables 19%. /14/ Other fruits 36%, other vegetables 24%, rice 3%, wheat 3%, and corn 3%. /15/ Other fruits 30%, other vegetables 33%, wheat

52. ZOO DIETS: MAMMALS, HERBIVORES (Continued)

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks. Differences in diet reflect climatic conditions, food availability, and individual variation within species. Body weights are only estimated and the amounts of food eaten are approximate only, and are for a single specimen of the species listed.

Composition of Diet (concluded)													
Crushed Oats	Bread	Apples	Avocados	Bananas	Cabbage Lettuce	Carrots	Celery	Potatoes	Horse Meat	Eggs	Grain Mix[1]	Misc.	Zoo[2]
g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	
(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)
	4	11	6		8	3		33		3		62[4]	SD
	3	14	5	8	19			7[3]				44[5]	SD
	7	9	17		9	3		33		2		50[6]	SD
		10		13	8	33	7		4	3		22[8]	NY
		11	3	11	9				3	3		60[10]	SD
	3	5		4	12	2	3	16[11]				55[12]	CHI
	6	13	6	23	13			63				33[13]	SD
	5	4	7		8			33		4		69[14]	SD
	4	3	7		7	3		43		7		65[15]	SD
	4	3			7			33		7		76[16]	SD
	9	10	5		9	3		33		4		57[17]	SD
		15		50					15			20[18]	NY
	6	15		29	115	7				6		20[19]	NY
	3	11		17	17	28			22	3		2[21]	NY
	4	18	5	3	15			63		3		46[22]	SD
	7	5	1		11	4		43		6		62[23]	SD
			14[24]		7	21					14		SD
			4[24]			8	11				7		SD
	4	3			11	4		9					NY
			5[24]			5	7				5		SD
			8			8	15				11		SD
											2		SD
			11[24]			9	11				9		SD
		2		11		3		3				16[26]	NY
			4[24]								4		SD
			4[24]				24				7		SD

1%, and rice 1%. /16/ Other fruits 35%, and other vegetables 37%. /17/ Other fruits 38%, other vegetables 12%, wheat 1%, rice 1%, and peanuts 4%. /18/ Oranges 20%. /19/ Evaporated milk 15%, canned dog food 3%, and grapes 2%. /20/ Plus one gallon of milk mixture per day, and 4 dog biscuits per day. /21/ Grapes 2%. /22/ Other fruits 21%, and other vegetables 25%. /23/ Other fruits 34%, other vegetables 22%, corn 2%, rice 2%, and wheat 2%. /24/ Values given are for winter months only; for other seasons eliminate avocados and recalculate values. /25/ Values for 10 months of the year; for remaining two months alfalfa pellets in half the quantity are substituted for fresh alfalfa. /26/ GLF formula, composed of: wheat bran 10%, hominy feed and corn meal 20%, 34 per cent linseed oil meal 10%, crushed oats 21%, cane molasses 10%, beet pulp 10%, chopped alfalfa 12%, wheat germ meal 3%, Brewer's yeast 2%, and salts 2%.

52. ZOO DIETS: MAMMALS, HERBIVORES (Continued)

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks. Differences in diet reflect climatic conditions, food availability, and individual variation within species. Body weights are only estimated and the amounts of food eaten are approximate only, and are for a single specimen of the species listed.

	Species	Sex	Body Weight	Total Feed per Week	Feed/kg Body Weight per Day	Composition of Diet				
						Alfalfa	Browse	Clover	Oat Hay	Timothy
			kg	kg	g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	ARTIODACTYLA (concluded)									
27	Camel, Dromedary (Camelus dromedarius)	F	595	48	12					
28	Deer, Axis (Axis maculatus)[24]	M	73	15	29	46[25]	31			
29	Deer, red (Cervus elaphus)[24]	F	159	28	25	49[25]	16			
30	Deer, sambar (C. unicolor equinus)[24]	M	181	34	25	48[25]	26			
31	Elk (Cervus canadensis canadensis)[24]	M	545	47	12	46[25]	10			
32	Gayal (Bibos frontalis)	F	455	84	26			57		
33	Gazelle, Arabian (Gazella gazella arabica)	M	14	12	122		7	53		
34	Giraffe, Uganda (Giraffa camelopardalis rothschildi)	M	1134	222	28	16[25]				
35	Giraffe, Uganda (G. camelopardalis rothschildi)	F	591	121	29			52		
36	Gnu, brindled (Connochaetes taurinus)[24]	M	295	45	22	60[25]	10			
37	Goat, tahr (Hermitragus jemlahicus jemlahicus)[24]	M	91	21	33	51[25]	15			
38	Guanaco (Lama huanacho)[24]	M	136	25	26	44[25]	18			
39	Hippopotamus (Hippopotamus amphibus)	M	1909	400	30	28		44		
40	Hippopotamus, pygmy (Choeropsis liberiensis)[24]	M	182	116	91	35[25]				
41	Kudu, greater (Strepsiceros strepsiceros)[24]	M	455	91	29	45[25]	13			
42	Llama (Lama glama)[24]	M	125	39	45	35[25]	12			
43	Moose (Alces alces andersoni)[24]	M	341	305	128		31			
44	Muntjac, Reeves (Muntiacus reevesi)[24]	F	11	9	117	31[25]	15			
45	Nilgai (Boselaphus tragocamelus)[24]	M	273	44	23	62[25]	10			
46	Okapi (Okapia johnstoni)	M	205	70	49			45		
47	Peccary, white-lipped (Tayassau pecari)	F	14	16	164					
48	Pronghorn (Antilocapra americana)[24]	M	57	18	45	37[25]	12			
49	Sheep, Canadian bighorn (Ovis canadensis c.)[24]	M	57	18	45	46[25]	12			
50	Sitatunga (Limnotragus spekii)	M	55	18	47			70		
51	Vicuna (Vicugna v. mensalis)[24]	M	45	27	86	5[25]	9		61	
52	Warthog (Phacochoerus aethiopicus)	F	55	31	81			52		

/1/ Grain mix feed composed of: beet pulp 30%, rolled barley 32%, bran 11%, rolled oats 8%, ground corn 11%, linseed meal 4%, bone meal 1%, and salts 1%. /2/ S. D. = San Diego Zoological Gardens, San Diego, California. N. Y. = New York Zoological Park, New York, N. Y. Chi. = Lincoln Park Zoo, Chicago, Ill. /24/ Values are for winter months only; for other seasons eliminate avocados and recalculate values. /25/ Values are for 10 months of the year; for remaining two months alfalfa pellets in half the quantity are substituted for fresh alfalfa. /26/ GLF formula, composed of: wheat bran 10%, hominy feed and corn meal 20%, 34 per

52. ZOO DIETS: MAMMALS, HERBIVORES (Continued)

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks. Differences in diet reflect climatic conditions, food availability, and individual variation within species. Body weights are only estimated and the amounts of food eaten are approximate only, and are for a single specimen of the species listed.

Composition of Diet (concluded)													
Crushed Oats	Bread	Apples	Avocados	Bananas	Cabbage Lettuce	Carrots	Celery	Potatoes	Horse Meat	Eggs	Grain Mix[1]	Misc.	Zoo[2]
g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	
(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)
												100[27]	NY
			9[24]			7					7		SD
			10[24]			10	5				10		SD
			8[24]			6	4				8		SD
			1[24]		12	17					1		SD
	6	1		6	8							22[28]	NY
		9				7		10				15[29]	NY
		16				11		7				50[30]	SD
	8	1		5	7	1		2				24[31]	NY
			9[24]			6	9				6		SD
			6[24]			6	13				9		SD
			11[24]			16					11		SD
												28[26]	NY
	5	5	1[24]		12	12	12	19					SD
		6	[illegible]		[illegible]	6	9				[illegible]		SD
			[illegible]			35					7		SD
		22	[illegible]		[illegible]	[illegible]		16[32]			7	21[33]	SD
			6[24]		16	13	15				4		SD
			6[24]			6	9				6		SD
	14	1		14	9	3						14[26]	NY
	5	13		5	20	5		41				11[34]	NY
			8		15	8	12				8		SD
			8[24]			8	15				11		SD
5	5	2		5	4	2		2				5[26]	NY
		10	[illegible]								5		SD
15	8	9		5	3	8							NY

cent linseed oil meal 10%, cru[illegible]ed oats 21%, cane molasses 10%, beet pulp 10%, chopped alfalfa 12%, wheat germ 3%, Brewer's yeast 2%, and [illegible]alts 2%. /27/ Timothy 67%, GLF formula 33% (see Fn 26). /28/ Crushed oats 11%, and GLF formula 11% (see Fn 26). /29/ Rolled oats 5%, crushed oats 5%, and grain mix 5% (see Fn 1). /30/ Acacia browse 37%, onions 5%, and grain mix 5% (see Fn 1). /31/ Crushed oats 12%, and GLF formula 12% (see Fn 26). /32/ For 6 months, then replaced by watermelon. /33/ Grapes for 6 months, then replaced by watermelon. /34/ GLF formula 8% (see Fn 26), and meat 2%.

52: ZOO DIETS: MAMMALS, HERBIVORES (Continued)

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks. Differences in diet reflect climatic conditions, food availability, and individual variation within species. Body weights are only estimated and the amounts of food eaten are approximate only, and are for a single specimen of the species listed.

	Species	Sex	Body Weight	Total Feed per Week	Feed/kg Body Weight per Day	Composition of Diet				
						Alfalfa	Browse	Clover	Oat Hay	Timothy
			kg	kg	g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	PROBOSCIDEA									
53	Elephant, African (Loxodonta a. africana)	F	3409	698	29	36				55
54	Elephant, African, forest (L. cyclotis)	M	2045	379	26	34				50
55	Elephant, Indian (Elaphas maximus)	F	2500	441	23	36				50
	PERISSODACTYLA									
56	Rhinoceros, black (Diceros bicornis)	M	1273	280	31	23				34
57	Rhinoceros, Indian (Rhinoceros unicornis)	F	1591	265	24	34				50
58	Tapir, Baird's (Tapirella bairdii)	M	136	112	118	57				
59	Tapir, South American (Tapirus terrestris)	F	227	47	30		10			
60	Zebra, Chapman's (Equus burchelli (antiquorum)	F	295	47	23				3	68
61	Zebra, Grevy's (E. grevyi)	M	409	57	20				13	84
	MARSUPIALIA									
62	Kangaroo, red (Macropus rufus rufus)	M	59	22	53			43		
63	Wallaby, agile (M. agilis)	F	5	8	280			42		
64	Wombat (Vombatus hirsutus)	F	9	4	63					

/1/ Grain mix feed composed of: beet pulp 32%, rolled barley 32%, bran 11%, rolled oats 8%, ground corn 11%, linseed meal 4%, bone meal 1%, and salts 1%. /2/ S. D. = San Diego Zoological Gardens, San Diego, California. N. Y. = New York Zoological Park, New York, N. Y. Chi. = Lincoln Park Zoo, Chicago, Ill. /26/ GLF

52. ZOO DIETS: MAMMALS, HERBIVORES (Concluded)

Diets illustrate the feeding practices successfully in use in the New York, Chicago and San Diego zoological parks. Differences in diet reflect climatic conditions, food availability, and individual variation within species. Body weights are only estimated and the amounts of food eaten are approximate only, and are for a single specimen of the species listed.

Composition of Diet (concluded)													
Crushed Oats	Bread	Apples	Avocados	Bananas	Cabbage Lettuce	Carrots	Celery	Potatoes	Horse Meat	Eggs	Grain Mix[1]	Misc.	Zoo[2]
g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	
(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)	(V)	(W)	(X)
3	1				1			2				3^{26}	NY
5	2				2			3				5^{26}	NY
4	2				2			3					NY
	3^{4}				2	2		2				2^{26}	NY
					3			8				5^{26}	NY
8	9	3				4		11				8^{26}	NY
	12	29	6^{24}		12			15^{3}			18		SD
29													NY
						3							NY
3	11	7		4	11	4		7				11^{35}	NY
	13	9		4	6	11		6				9^{35}	NY
12	24	20		8		12		12				12^{35}	NY

formula, composed of: wheat bran 10%, hominy feed and corn meal 20%, 34 per cent linseed oil meal 10%, crushed oats 21%, cane molasses 10%, beet pulp 10%, chopped alfalfa 12%, wheat germ meal 3%, Brewer's yeast 2%, and salts 2%.

53. ZOO DIETS: BIRDS

Diets illustrate the feeding practices successfully in use in the New York and San Diego zoological parks. Differences in diet reflect climatic conditions, food availability, and individual variation within species. Body weights are only estimated and the amounts of food eaten are approximate only, and are for a single specimen of the species listed.

	Species	Wt.	Total Feed per Week	Feed per kg Body Weight per Day	Composition of Diet													Zoo[1]
					Meat	Butter-fish	Anchovies and Sardines	Fish-general	Bread	Barley	Rolled oats	Apples	Bananas	Oranges	Fruit, general	Lettuce	Misc.	
		kg	kg	g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)
	STRUTHIONIFORMES																	
1	Ostrich, North African (Struthio camelus camelus)	114	14	18	24				18	23						23	12[2]	SD
2	Ostrich, South African (S. camelus australis)	68	18[3]	38	6	10			18		13	12				27	14[4]	NY
	CASUARIIFORMES																	
3	Cassowary, Bennett, one-wattled (Casuarius unappendiculatus occipitalis)	45	21[5]	67	4							31	15		31		19[6]	SD
4	Cassowary, violet-necked (C. casuarius aruensis)	39	11[7]	40	5	7			57			10	7	14				NY
5	Emu (Dromiceius novaehollandiae)	27	10	53	6				32		11	16				24	11[4]	NY
6	Emu (D. novaehollandiae)	45	14	44	6				18	24		29				24		SD
	PELECANIFORMES																	
7	Pelican, eastern, brown (Pelecanus carolinensis occidentalis)	4	5[8]	179		100												NY
8	Pelican, eastern, white (P.onocrotalus)	7	8	160			100											SD
9	Pelican, European, white(P.occidentalis onocrotalus)	6	7[8]	167		100												NY
10	Pelican, Peruvian (P. occidentalis thagus)	5	7	200			100											SD
	SPHENISCIFORMES																	
11	Penguin, king (Aptenodytes patagonica patagonica)	20	11[9]	79				100[10]										NY
12	Penguin, rock-hopper (Eudyptes crestatus crestatus)	3	4[9]	190				100[11]										NY
	CICONIIFORMES																	
	Adjutant, Indian (Leptoptilos dubius	8	7	125	14[12]	86												NY
	Adjutant, Indian (L. dubius)	11	2	168			100											SD
	Heron, cocoi (Ardea cocoi)	2	1	71		100												NY
16	Shoebill (Balaeniceps rex)	7	6	122		100												NY
17	Shoebill (B. rex)	5	8	228			40										60[13]	SD
	FALCONIFORMES																	
18	Condor, andean (Vultur gryphus)	23	6	37[14]			100											SD
19	Condor, andean (V. gryphus)	10	5	71[14]	100													NY
20	Eagle, bald (Haliaeetus leucocephalus washingtoniensis)	3	2	95			100											SD
21	Eagle, southern, bald (H. leucocephalus leucocephalus)	6	3	71	65	35												NY
	CHARADRIIFORMES																	
22	Gull, great, black-necked (Larus marinus)	2	2	143		100												NY
	STRIGIFORMES																	
23	Owl, snowy (Nyctea scandiaca)	1	1	143	100													NY
24	Owl, snowy (N. scandiaca)	1	1	143			100											SD

/1/ NY: New York Zoological Park, New York, N. Y. SD: San Diego Zoological Gardens, San Diego, California. /2/ Alfalfa. /3/ Supplemented with 1 quart whole corn daily in cold months, and 1 quart scratch grain daily in warm months. /4/ GLF formula, consisting of: wheat bran 10%, hominy feed and corn meal 20%, 34 percent linseed nil meal 10%, crushed oats 21%, cane molasses 10%, beet pulp 10%, chopped alfalfa 12%, wheat germ meal 3%, brewer's yeast,2%, salts 1%. /5/ Supplemented with 28 mice per week. /6/ Tomatoes. /7/ Supplemented with 7 rats per week. /8/ Eats about 50% more daily for 2 autumn months. /9/ Penguins eat almost twice as much for ten days before and after annual moult: during moult (10-15 days) there is almost complete inappetence. /10/ Mackerel. /11/ Smelts. /12/ Rat per week sometimes substituted. /13/ Liver. /14/ 4 rats per month sometimes substituted.

54. REPRESENTATIVE SYNTHETIC DIETS: INSECTS

Diets are representative diets for a number of insects which have been extensively studied in nutritional research. Insects maintained on sterile diets arise from eggs rendered bacteria free.

Nutrient \ Organism	Orthoptera		Coleoptera	Lepidoptera		Diptera	
	German cockroach (Blatella germanica (L.)) Nymphs and adults	German cockroach (Blatella germanica (L.)) Nymphs and Adults	Mealworm[1], yellow (Tenebrio molitor L.) Larvae	Flour moth (Ephestia sp.) Larvae	Corn borer (Pyrausta nubilialis) Larvae	Fruit fly (Drosophila melanogaster) Larvae	Mosquito, yellow fever (Aedes aegypti L.) Larvae
	Type of Medium						
	Solid Not Sterile[2]	Solid Sterile[3]	Solid Not Sterile[2]	Solid Not Sterile[4]	Agar Base Sterile[2]	Agar Base Sterile[2]	Liquid and Solid, Sterile[4]
	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 ml[5]	per 100 ml[5]
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Proteins, Protein Derivatives						
1 Casein[6], g	30.0	29.0	17.0	17.0	4.0		0.6
2 Cystine, mg							20.0
3 Glutathione, mg							1.0
4 Amino-acid mixture[7], g						2.4	
	Carbohydrates						
5 Dextrin, g		63.0					
6 Glucose, g	31.0		69.0	68.0	4.0		
7 Sucrose, g						0.75	0.2
	Lipids						
8 Corn oil, g	3.0						
9 Soy bean oil, g		1.0					
10 Wheat germ oil, g				1.0			
11 Cholesterol[8], g	1.0	0.5	0.9	1.0	0.15	0.04	0.003
12 Ergosterol, g		0.5					
13 Lecithin, g							
14 Linoleic acid, g					0.15		
	Vitamins and Growth Factors						
15 Biotin, mg	0.06	0.025	0.02	0.02		0.003	0.005
16 Cobalamin[9], mg						0.004	
17 Carnitine, mg			0.15				
18 Choline[10], mg	400.0	100.0	30.0	50.0	0.06	7.5	2.0
19 Inositol, mg	200.0	97.0		50.0			4.0
20 Niacin, mg	10.0	10.0	1.6	5.0			0.2

/1/ A diet also suitable for the confused flour beetle (Tribolium c nfusum) and Palorus ratzeburgi; carnitine is not required by T. confusum. /2/ Supports rapid growth relative to growth on adequate crude diets. /3/ Supports slow growth relative to growth on adequate crude diets. /4/ Supports fair growth relative to growth on adequate crude diets. /5/ Calculated as grams or milligrams/100 grams of diet and figures rounded. /6/ Vitamin free. /7/ A mixture of 18 pure amino-acids. /8/ Cholesterol is an essential substance for all insects which have been critically studied. /9/ Vitamin B_{12}. /10/ As the chloride.

54. REPRESENTATIVE SYNTHETIC DIETS: INSECTS (Concluded)

Diets are representative diets for a number of insects which have been extensively studied in nutritional research. Insects maintained on sterile diets arise from eggs rendered bacteria free.

	Orthoptera		Coleoptera	Lepidoptera		Diptera	
Organism	German cockroach (Blatella germanica (L.)) Nymphs and adults	German cockroach (Blatella germanica (L.)) Nymphs and adults	Mealworm[1] (Tenebrio molitor) Larvae	Flour moth (Ephestia sp.) Larvae	Corn borer (Pyrausta nubilialis) Larvae	Fruit fly (Drosophila melanogaster) Larvae	Mosquito (Aedes aegypti) Larvae
Nutrient / Type of Medium	Solid Not Sterile[2]	Solid Sterile[3]	Solid Not Sterile[2]	Solid Not Sterile[4]	Agar Base Sterile[2]	Agar Base Sterile[2]	Liquid and Solid, Sterile[4]
	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 g[5]	per 100 ml[5]	per 100 ml[5]
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Vitamins and Growth Factors (concluded)							
21 Niacinamide, mg						1.0	1.0
22 Pantothenic acid[11], mg	4.0	10.0	0.8	5.0		0.6	0.6
23 Para-aminobenzoic acid, mg		10.0					0.2
24 Pteroylglutamic acid, mg	0.5	0.4	0.0125-0.0250	0.2		0.6	0.06
25 Pyridoxine[12], mg	1.6	10.0	0.2	5.0		0.3	0.4
26 Pyridoxamine[13], mg							0.002
27 Riboflavine, mg	1.8	10.0	0.2-0.8	5.0		0.24	0.2
28 Thiamine[12], mg	1.2	10.0	0.1	5.0		0.15	0.2
Other Nutritional Factors							
29 Brewer's yeast, g					1.50		
30 Leaf factor[14], g					1.2		
31 Ribonucleic acid, g		0.5				0.1	0.1
Minerals							
32 $CaCl_2$[15], mg						1.3	1.2
33 $FeSO_4$[15], mg						1.3	1.2
34 K_2HPO_4[15], mg						61.0	60.0
35 KH_2PO_4[15], mg						61.0	60.0
36 $MgSO_4.7H_2O$[15], mg						25.0	20.0
37 $MnSO_4.7H_2O$[15], mg						1.3	1.2
38 NaCl[15], mg						1.3	1.2
39 McCollum's mixture 185[16], g			2.0	2.0			
40 U.S.P. No. 1[17], g		3.0					
41 Wesson's mixture[18], g	4.0				0.30		
Other Ingredients							
42 Agar-agar, g					2.3	2.0	
43 Cellulose, g	30.0				1.8		
44 Water, ml		2.0	9.0		100.0	100.0	100.0

/1/ A diet also suitable for the confused flour beetle (Tribolium confusum) and Palorus ratzeburgi; carnitine is not required by T. confusum. /2/ Supports rapid growth relative to growth on adequate crude diets. /3/ Supports slow growth relative to growth on adequate crude diets. /4/ Supports fair growth relative to growth on adequate crude diets. /5/ Calculated as grams or milligrams/100 grams of diet and figures rounded. /11/ As calcium pantothenate. /12/ As the hydrochloride. /13/ As the dihydrochloride. /14/ From Cerophyl Laboratories, Inc. /15/ Ingredient of Tatum's salt mixture for which see Ref. 14. /16/ For which see Ref. 15. /17/ For which see Ref. 16. /18/ For which see Ref. 17.

55. SELECTED SOURCES FOR CERTAIN NUTRIENTS

Foods listed are important sources of nutrients indicated. Data do not take into account, however, food habits or costs, which may lead to use of foodstuffs not listed as chief source of a nutrient. Values, in the units specified, are per 100 grams of edible portion of uncooked foodstuff, unless otherwise indicated.

Nutrients (A)	Sources and Nutritive Value (B)
Food energy, Calories[1]	Cheese (except cottage): 300-400 Cooking & table fats, salad oils: 700-900 Grain products, dry: 330-390 Nuts: treenuts, peanuts: 560-700 Salt pork, bacon, other fat meats: 600-800 Sugars: 370-385
Protein, g	Eggs: 13 Grains: 8-14 Legumes, mature, dry: 21-35 Meat, poultry, fish: 16-20 Milk: 3-4
Carbohydrate, g	Fruit, dried: 67-73 Grains: 70-80 Legumes, mature, dry (except soybeans): 60-64 Potatoes, sweetpotatoes: 19-28 Sugars: 90-100
Fat, g	Cheese (except cottage): 25-37 Cooking and table fats, salad oils: 81-100 Cream: 20-35 Nuts: 54-73 Salt pork, bacon, other fat meats: 55-85
Vitamin A, calc. as β-carotene[2], mg	Butter, margarine with vit. A added: 1.9 Carrots: 7.2 Greens, all kinds: 1.8-5.7 Liver, all kinds: 8.5-30.3 Sweetpotatoes: 4.6
Ascorbic acid, mg	Various berries[3]: 16-60 Cabbage: 50 Citrus fruit: 40-50 Greens: collards, kale, mustard, turnip: 100-136 Potatoes, sweetpotatoes: 17-22 Tomatoes: 23
Choline, mg	Beans, snap: 340; peas: 260 Egg yolk: 1130-1700 Liver: 470-700 Peanuts: 160-170 Soybeans: 300-340; spinach: 240 Wheat germ: 400
Cobalamin as vitamin B_{12}[4]	Liver and kidney: high Milk, muscle meats, fish: medium Corn, soybeans, wheat, yeast: low
Vitamin D, calc. as calciferol, μg[5]	Egg yolk, dried: 6.6 Fish, canned: pilchard: 18.6; salmon: 7.9; sardines: 34 Fish, raw, fresh: herring: 7.9; mackerel: 28 Liver, all kinds: 0.2-1.4 Shrimp: 3.8
Tocopherol, mg	Beans, navy, dry: 3.6 Butter: 2.4; margarine: 54 Eggs, whole: 2 Corn oil: 87; peanut oil: 22; soybean oil: 140
Folic acid, μg	Asparagus: 89-142; broccoli: 34 Beans, navy, dry: 129; corn, sweet: 9-70 Cheese, cottage: 21-46 Dates, dry: 25 Greens: collards, kale, mustard, etc.: 20-115 Liver: 220-290 Nuts: 27-77
Vitamin K, μg	Cabbage, cauliflower: 250-275 Liver, pork: 115-230 Oats: 75; soybeans: 190 Spinach: 334 Wheat bran: 80
Niacin, mg	Beef, lamb, pork: 2.6-5.2 Fish[6], poultry, veal: 5.6-10.5 Liver, all kinds: 13.7-16.9 Peanuts: 16.2 Wheat, other grain products, whole or enriched: 2-5
Pantothenic acid, mg	Beans, lima, dry: 0.8 Bralns, beef: 2.1-2.9 Broccoli: 1.4; mushrooms: 1.7 Eggs: 2.7; liver, beef and pork: 5.7-8.2 Peanuts, roasted: 2.5 Wheat bran: 2.4
Pyridoxine, mg	Bananas; cabbage; peanuts, roasted; sweetpotatoes: 0.3 Beans, lima, dry: 0.5 Halibut: 0.1 Liver, beef: 0.8; pork loin: 0.1-0.3 Wheat, whole: 0.2; wheat germ: 0.6
Riboflavine, mg	Eggs: 0.3 Greens: collards, kale, turnip: 0.3-0.5 Liver, all kinds: 2.5-3.9 Meats, poultry: 0.1-0.3 Milk: 0.2
Thiamine, mg	Legumes, mature, dry: 0.5-1.1 Nuts: treenuts, peanuts: 0.2-0.9 Pork: 0.5-0.8 Brown rice, rye, corn: 0.3-0.4 Whole wheat, oatmeal: 0.4-0.6
Calcium, mg	Cheese: Cheddar type: 670-725 Fish, canned with edible bone: 150-400 Greens: collards, kale, mustard, turnip: 220-259 Milk: 118 Soybeans, soy flours: 195-265
Iron, mg	Egg yolk: 7.2 Greens: collards, kale, mustard, spinach, turnip: 1.6-3.0 Legumes, mature, dry: 4.7-8.0 Liver, all kinds: 6.6-18.0 Wheat: 3.0-4.3

/1/ Kilocalories. /2/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity. 0.0006 mg β-carotene or 0.0003 vitamin A alcohol = one I. U. /3/ Include blackberry, blueberry, gooseberry, loganberry, raspberry, strawberry. /4/ Quantitative data not available. /5/ 0.025 μg = one I. U. /6/ Include Atlantic mackerel, halibut, salmon, swordfish.

56. BALANCED SALT SOLUTIONS FOR ISOLATED ANIMAL TISSUES

Physiological balanced salt solutions are used for washing cells or tissues, and for the dilution of nutrients for various animal cells. In general, these salt solutions will support life of isolated animals tissues for a short time, but they are not suitable for long-term maintenance or growth.

	Component \ Solution	Locke	Pannett and Compton	Holt-freter[1]	Tyrode	Parker's "Glucosol"	Baker I[2]	Baker II[3]	Gey I	Gey II	Earle	White[4]	Hanks	Way-mouth[4]	Simms[5]
		mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
1	Calcium chloride, $CaCl_2$	240	150	100	200	200	172	150	170	130	200		140		111
2	Calcium nitrate, $Ca(NO_3)_2.H_2O$											210		200	
3	Ferric nitrate, $Fe(NO_3)_3.9H_2O$											1.3			
4	Magnesium chloride, $MgCl_2.6H_2O$		500		214[6]	100	90	75	210	210			100	100	203
5	Magnesium sulfate, $MgSO_4.7H_2O$								70		200	562[6]	100		
6	Potassium chloride, KCl	420	600	50	200	200	180	150	370	380	400	375	400	200	200
7	Potassium orthophosphate, KH_2PO_4								30	25		26	60	25	
8	Potassium sulfate, K_2SO_4														
9	Sodium bicarbonate, $NaHCO_3$	300		100	1000		1000	750	2270	250	2200	550	350	560	1010
10	Sodium chloride, NaCl	9000	4800	3500	8000	8000	7200	5810	7000	8000	6800	7000	8000	7000	8000
11	Sodium orthophosphate, mono-H, Na_2HPO_4								120	120		57.5[7]	60	57.5	213
12	Sodium orthophosphate, di-H, $NaH_2PO_4.H_2O$				57[6]	50	52[6]	43[6]			125				
13	Glucose	1000[8]			1000	1000	1000	2000	1000	1000	1000	8500	1000	6000	1000

/1/ For amphibian tissues. /2/ For fibroblasts and epithelium. /3/ For monocytes. /4/ For use with synthetic media. /5/ X-6 solution for adult fibroblasts. /6/ Quantity of anhydrous salt here specified is calculated from quantity of hydrated salt used in original formulation. /7/ Quantity of hydrated salt here specified is calculated from quantity of anhydrous salt used in original formulation. /8/ Glucose may be omitted from the solution.

57. NUTRIENT SOLUTIONS: HIGHER PLANTS

Distilled or deionized water should be used wherever possible and the initial volume of the solution should be maintained. To avoid serious depletion, the solution is renewed as often as necessary. The frequency of renewal depends on the volume of the solution in relation to the mass of growing plant material and environmental conditions.

	Compound	Solution	
		Hoagland, D.R., and Arnon, D.I., 1950[1]	Robbins, W.R., 1952[1]
		mg/L	mg/L
	(A)	(B)	(C)
1	H_3BO_3	2.86	0.57
2	$Ca(NO_3)_2.4H_2O$	945	1181
3	$CuSO_4.5H_2O$	0.08	0.04
4	$FeSO_4.7H_2O$[2,3]	5	2.49
5	$MgSO_4.7H_2O$	493	493
6	$MnCl_2.4H_2O$	1.81	
7	$MnSO_4.4H_2O$		1.02
8	$H_2MoO_4.H_2O$	0.02	0.02
9	$NH_4H_2PO_4$	115	
10	KH_2PO_4		136
11	KNO_3	606	
12	K_2SO_4		348
13	$ZnSO_4.7H_2O$	0.22	0.22

/1/ Among other satisfactory solutions are those of: Withrow, R. B., and Withrow, A. P.; Shive, J. W., and Robbins, W. R.; Thimann. K. V., and Edmondson, Y. H.; Chapman, H. D.; Brown, S. M., and Rayner, D. S.; Haas, A. R. C., Steinberg, R. A.; Smith, P. F.; Stewart, W. D., Youden, W. J., and Arthur, J. M. /2/ To be added twice weekly or as indicated by the appearance of plants. /3/ Equivalent amounts of iron may be supplied as organic iron salts, i.e.,iron tartrate or K-Fe-ethylene diamine tetra-acetate.

58. CULTURE MEDIA: ISOLATED PLANT TISSUES

Values are mg or grams, as specified, per liter of culture solution.

	Tissue and Species / Compound	Callus[1]					Embryo[2]		Root Tips[3]		Stem Tips	Tumor	
		Artichoke, Jerusalem[4] (Helianthus tuberosa)	Cabbage[5] (Brassica oleracea capitata)	Carrot[6] (Daucus carota)	Hawthorn[7] (Crataegus monogyna)	Tobacco[8] (Nicotiana tabacum)	Cherry, sweet[9] (Prunus avium)	Ketelieria[10] (Ketelieria davidiana)	Buckwheat[11,12] (Fagopyrum esculentum)	Tomato[13] (Lycopersicon esculentum)	Asparagus[14] (Asparagus officinalis)	Marigold, African[15,16] (Tagetes erecta)	Sunflower[11,17] (Helianthus annuus)
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
	Major Salts												
1	Calcium nitrate, $Ca(NO_3)_2.4H_2O$, mg	290	290	290	290	140		470	140	480	240	800	290
2	Calcium mono-orthophosphate, $CaH_4P_2O_8$, mg												
3	Calcium sulfate, $CaSO_4$, mg	0.2	0.2		0.2		170						
4	Calcium tri-orthophosphate, $Ca_3(PO_4)_2$, mg						170						
5	Ferrous orthophosphate, $Fe_3(PO_4)_2$, mg						170						
6	Ferric sulfate, $Fe_2(SO_4.6H_2O)_3$, mg	20	20	2.5	20	2.5		1.9[18]	2.5	2.5			2.5
7	Ferric tartrate, $Fe_2(C_4H_4O_6)_3$, mg										1.5	5	
8	Magnesium sulfate, $MgSO_4.7H_2O$, mg	72	72	360	72	72	350	98	74	63	36	720	360
9	Potassium chloride, KCl, mg	72	72	65	72	65	680	74	65	42	65	130	65
10	Potassium nitrate, KNO_3, mg	72	72	80	72	80	130	80	80	63	81	160	80
11	Potassium orthophosphate, di-H, $KH_2PO_4.H_2O$, mg	72	72		72	12.5		13	12.3	60	20		
12	Sodium orthophosphate, di-H, $NaH_2PO_4 . H_2O$, mg			16.5								130	16.5
13	Sodium sulfate, Na_2SO_4, mg			200								100	200

	Minor Salts												
14	Boric acid, H_3BO_3, mg			1.5	0.02	1.6			1.5	0.1		3.0	1.5
15	Manganese sulfate, $MnSO_4.4H_2O$, mg	0.4	0.4	4.5	0.4	4.4			4.5			4.5	4.5
16	Potassium iodide, KI, mg			0.8		0.8			0.8			0.4	0.8
17	Zinc sulfate, $ZnSO_4.7H_2O$, mg	0.2[19]	0.2[19]	1.5	0.2[19]	1.5			1.5	0.1		3.0	1.5
	Carbohydrates and Vitamins												
18	Glucose, g	20	20		50		5						
19	Sucrose, g			20		20		20	20	20	10	20	20
20	Ascorbic acid, mg							10					
21	Folic acid, mg		10										
22	Niacin, mg					0.5		1.0					1.0
23	Pyridoxine, mg					0.5		0.1		0.2		0.8	0.1
24	Thiamine, mg					0.1		0.1		0.2		0.1	0.1
	Other Compounds												
25	Adenine sulfate, mg					40[20]							
26	Agar, g	12	12	8	12	7	6.5	6			5	6.0	7
27	Calcium pantothenate, mg				1.0								
28	Coconut milk, g			150									
29	Glycine, mg			3		2						12	3
30	Indoleacetic acid, mg	0.1		0.01-10				10					
31	Naphthaleneacetic acid, mg		0.1		0.3								
32	Yeast extract, mg								100				

/1/ Additional media for callus tissue, other than those presented in table, have been reported by G. Morel; G. Morel and R. H. Wetmore; P. Nobecourt; P. Nebecourt and L. Kofler; J. P. Nitsch; L. Duhamet; E. Ball; R. J. Gautheret; A. C. Hildebrandt and A. J. Riker; L. G. Nickell, P. Greenfield and P. R. Burkholder. /2/ Additional media for embryo tissue, other than those presented in table, have been reported by J. Bonner and D. Bonner; J. van Overbeek, M. F. Conklin, and A. F. Blakeslee. /3/ Additional media for root tip culture, other than those presented in table, have been reported by P. R. White; W. G. Boll and H. E. Street; K. J. Dormer and H. E. Street; H. E. Street and J. S. Lowe; J. Bonner; J. Bonner and F. Addicot; J. Bonner and P. S. Devirian; J. E. McClary; V. Slankis. /4/ Medium reported by P. Nobecourt. Also applicable to salsify (Tragopogon porrifolius and Scorzonera hispanica). /5/ Medium reported by R. J. Gautheret. Also applicable to Jerusalem artichoke (Helianthus tuberosa), carrot (Daucus carota), chicory (Cichorium intibus), salsify (Tragopogon porrifolius). /6/ Medium reported by S. M. Caplin and F. C. Steward. /7/ Medium reported by G. Morel. /8/ Medium reported by F. Skoog and C. Tsui. /9/ Medium reported by H. B. Tukey. Also applicable to sour cherry (Prunus cerasus), peach (P. persica), plum (P. americana), apple (Pyrus malus), pear (P. communis). /10/ Medium reported by S. Loo and F. H. Wang. Also applicable to pine (Pinus yunnanensis). /11/ Medium reported by P. R. White. /12/ Also applicable to many other plants including radish (Raphanus sativus), tobacco (Nicotiana tabacum), tomato (Lycopersicon esculentum), various legumes. /13/ Medium reported by W. J. Robbins and M. B. Schmidt. /14/ Medium reported by S. Loo. Also applicable to dodder (Cuscuta campestris). /15/ Medium reported by A. C. Hildebrandt, A. J. Riker, and B. M. Duggar. Also applicable to sunflower (Helianthus annuus). /16/ Additional media for tumor tissue, other than those presented in table, have been reported by A. C. Hildebrandt et al. /17/ Also applicable to many other plants including Jerusalem artichoke (Helianthus tuberosa), Marguerite chrysanthemum (Chrysanthemum frutescens), carrot (Daucus carota). /18/ The original medium was reported as 1.6 mg $FeCl_3$. /19/ Additional minor salts consist of 0.01 mg each of $CuSO_4$, $NiCl_2$ and $CoCl_2$; 0.8 mg $Ti_2(SO_4)_3$. /20/ Unnecessary for growth but promotes formation of buds.

59. CULTURE MEDIA: FUNGI

Fungi require oxygen, obtainable from gas dissolved in the culture medium, or, in the case of surface growth, from the atmosphere. An organic source of carbon is required. Most species can utilize ammonium nitrogen, and many also nitrate nitrogen. An occasional species may be unable to synthesize a specific amino acid. Most fungi can synthesize all vitamins they require.

	Constituents \ Organism	Aspergilli and Penicillia[1]	Basidiomycetes Wood Rotting Types[2]	Neurospora[3]	Saccharomyces cerevisiae (Certain Strains)[4]
		mg/liter	mg/liter	mg/liter	mg/liter
	(A)	(B)	(C)	(D)	(E)
	Salts				
1	Ammonium molybdate, $(NH_4)_6Mo_7O_{24}\cdot 4H_2O$		0.018		
2	Ammonium nitrate, NH_4NO_3			1,000	
3	Ammonium orthophosphate, di-H, $NH_4H_2PO_4$				6,000
4	Ammonium tartrate, $(NH_4)_2C_4H_4O_6$			5,000	
5	Boric acid, H_3BO_3		0.57	0.057	
6	Calcium chloride, $CaCl_2$			100	
7	Copper sulfate, $CuSO_4\cdot 5H_2O$		0.039	0.397	0.097
8	Ferric chloride, $FeCl_3\cdot 6H_2O$			0.960	0.72
9	Ferrous sulfate, $FeSO_4\cdot 7H_2O$	10	0.15	0.980[5]	
10	Magnesium sulfate, $MgSO_4\cdot 7H_2O$	500	500	500	250
11	Manganese chloride, $MnCl_2\cdot 4H_2O$		0.036	0.072	
12	Potassium chloride, KCl	500			
13	Potassium orthophosphate, mono-H, K_2HPO_4	1,000			
14	Potassium orthophosphate, di-H, KH_2PO_4		1,500	1,000	200
15	Sodium chloride, NaCl			100	
16	Sodium molybdate, Na_2MoO_4			0.042	
17	Sodium nitrate, $NaNO_3$	3,000			
18	Zinc chloride, $ZnCl_2$			4.2	
19	Zinc sulfate, $ZnSO_4\cdot 7H_2O$		0.31	8.8[6]	1.8
	Carbohydrates				
20	Glucose		10,000		10,000
21	Sucrose	30,000		15,000	
	Amino Acids				
22	Asparagine				2,500
23	Glutamic acid		1,260[8]		
	Vitamins[7]				
24	Biotin			0.005	0.02
25	Pyridoxine-HCl				1.0
26	Thiamine-HCl		1.00[9]		4.0
	Other Constitutents				
27	Calcium pantothenate				0.5
28	Sodium citrate				1,000

/1/ Dox's modification of Czapek's medium. /2/ Minimal medium for shake culture. /3/Medium for wild-type strains. /4/ Variation in strains and cultural conditions require variation in composition of solution. See bibliographic reference. /5/ May be substituted for constituent 8D. /6/ May be substituted for constituent 18D. /7/ Certain strains of Saccharomyces cerevisiae require also nicotinamide and para-aminobenzoic acid. /8/ Same amount of asparagine may be used in place of glutamic acid. /9/ Thiamine required by most, but not all, wood-rotting basidiomycetes. Some require biotin and/or riboflavine.

60. CULTURE MEDIA: ALGAE

The atmosphere provides sufficient carbon for growth of most species in light. In laboratory cultures, however, most species give better rates and yields of growth if 1-5% CO_2 in air is bubbled through the culture. For those algae that can be cultivated in darkness an organic source of carbon must be provided. Oxygen is utilized from the atmosphere. Water serves as the source of hydrogen and as a sufficient source also of oxygen in the case of many blue-green algae, which are capable of good growth under anaerobic conditions even if sulfide is present. Beneficial use of such chelating agents as ethylenediaminetetraacetic acid (EDTN), will permit the safe use of micronutrients in greater concentration, and often improve growth significantly.

Compound \ Medium	General[1]	Myers[2,3]	Allison[4]	Emerson Lewis[5]	Chu No. 10[5]	Allen[5,6]	Artificial Sea Water[7]
	mg/100 ml	mg/100 ml	mg/100 ml	mg/100 ml	mg/100 ml	mg/100 ml	mg/100 ml
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
1 Ammonium chloride, NH_4Cl				5		5	
2 Ammonium metavanadate, NH_4VO_3	0.0022[8]	0.0022[8]	0.0022[8]	0.0022[8]	0.0022[8]	0.0022[8]	
3 Boric acid, H_3BO_3	0.286[9]	0.286[9]	0.286[9]	0.286[9]	0.286[9]	0.286[9]	
4 Calcium chloride, $CaCl_2$	4-40			2		5	
5 Calcium nitrate, $Ca(NO_3)_2$					4		
6 Calcium sulfate, $CaSO_4$			10[10]				100
7 Chromic potassium sulfate, $Cr_2K_2(SO_4)_4.24H_2O$	0.019[8]	0.019[8]	0.019[8]	0.019[8]	0.019[8]	0.019[8]	
8 Citric acid, $C_6H_8O_7$							
9 Cobalt nitrate(ous), $Co(NO_3)_2.6H_2O$	0.0049[8]	0.0049[8]	0.0049[8]	0.0049[8]	0.0049[8]	0.0049[8]	
10 Copper sulfate, $CuSO_4.5H_2O$	0.0079	0.0079[9]	0.0079[9]	0.0079[9]	0.0079[9]	0.0079[9]	
11 Ferric chloride, $FeCl_3$	1-2		0.5				
12 Ferric citrate					0.3		
13 Ferric sulfate, $Fe_2(SO_4)_3$		5					
14 Ferrous sulfate, $FeSO_4$				0.4		Trace	
15 Magnesium chloride, $MgCl_2$							370-500
16 Magnesium sulfate, $MgSO_4.7H_2O$	10-40	250	20	25	2.5	25	170-500
17 Manganese chloride, $MnCl_2.4H_2O$	0.181[9]	0.181[9]	0.181[9]	0.181[9]	0.181[9]	0.181[9]	
18 Molybdenum oxide, MoO_3	0.0015[8]	0.0015[8]	0.0015[8]	0.0015[8]	0.0015[8]	0.0015[8]	
19 Nickel sulfate, $NiSO_4.6H_2O$	0.0048[8]	0.0048[8]	0.0048[8]	0.0048[8]	0.0048[8]	0.0048[8]	
20 Potassium chloride, KCl							70-1000
21 Potassium nitrate, KNO_3	20-100	120		100			
22 Potassium orthophosphate, mono-H, K_2HPO_4	10-40		50		1	25	
23 Potassium orthophosphate, di-H, KH_2PO_4		120		100			
24 Sodium carbonate, Na_2CO_3				150	2		
25 Sodium chloride, NaCl			20				2600-3000
26 Sodium citrate		20					
27 Sodium metasilicate, Na_2SiO_3					2.5		
28 Sodium nitrate, $NaNO_3$						100	
29 Sodium tungstate, $Na_2WO_4.2H_2O$	0.0017[8]	0.0017[8]	0.0017[8]	0.0017[8]	0.0017[8]	0.0017[8]	
30 Titanium oxysulfate, $TiOSO_4$	0.003[8]	0.003[8]	0.003[8]	0.003[8]	0.003[8]	0.003[8]	
31 Zinc sulfate, $ZnSO_4.7H_2O$	0.0022[9]	0.0022[9]	0.0022[9]	0.0022[9]	0.0022[9]	0.0022[9]	

/1/ The ranges of the concentrations of compounds as given in column B include the quantities specified for the media of Knop, Benecke, Molisch, Miquel, and Beijerinck. These have been widely used for cultivation of relatively hardy green and other algae. Differences between these media are probably not significant for most purposes. $Ca(NO_3)_2$ or NH_4NO_3 may be substituted for KNO_3 (a few algae require ammonia nitrogen); KH_2PO_4 may be substituted for K_2HPO_4 for those algae which prefer an acidic environment; $CaSO_4$ may be used instead of $CaCl_2$, and $FeSO_4$ may replace $FeCl_2$. Addition of 0.1% glucose and 0.2% beef extract is useful for maintenance of stock cultures. For marine algae natural sea water or artificial sea water (cf. column H) may be used with the medium. /2/ Medium is excellent for the widely-grown Chlorella. pH adjusted to 4.5-6.8. $MgSO_4.7H_2O$ may be reduced to 50 to prevent precipitation on autoclaving. Carbon is best provided by passing 5% CO_2 in air through the culture. /3/ Similar media, e.g., Warburg's and Emerson's are available in the literature (ref. 10,11). /4/ Used in the cultivation of the nitrogen-fixing algae. Drewes' medium which is similar is available in the literature (ref. 2). /5/ Used for the cultivation of planktonic algae (blue-green, greens, diatoms). Similar media, e.g., Richter's, Pringsheim's, and Harden's are available in the literature (ref. 2). /6/ The addition of 100 mg/100 ml sodium glutamate is desirable for some algae. /7/ The formula includes various artificial sea water media, e. g., Perrier's, Herbst's, and Pringsheim's. /8/ Not specified as part of named solution, but added as a component of Arnon's micronutrient solution B7, for beneficial effect on growth. /9/ Not specified as part of named solution, but added as a component of Arnon's micronutrient solution A4, for possible beneficial effect on growth. /10/ Also: 100-500 mg/100 ml, $CaCO_3$.

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61. CULTURE MEDIA: CERTAIN BACTERIA

Values are mg of the nutrient per liter of culture solution.

	Organism / Components	Bacillus subtilis	Hemophilus parainfluenzae	Lactobacillus arabinosus[1]	L. arabinosus strain 17-5[2]	L. lactis	L. leichmannii	L. leichmannii strains 313 and 327	Leuconostoc citrovorum strain 8081	Streptococcus faecalis
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	Amino acids[3]									
1	Alanine		1,000	1,000	100	200	200	100	100	500
2	Arginine.HCl		400	400	100	400	200	100	200	400
3	Asparagine	2,000			400	400	200		400	500
4	Aspartic acid		1,000	1,000	400	200	200	400	100	500
5	Cysteine						800	400[4]	50	
6	Cystine		200	200	200	400	400			200
7	Glutamic acid	2,000	2,000	2,000	400	400	400	400	300	1,000
8	Glutamine						100			
9	Glycine		100	100	100	200	300	100	100	100
10	Histidine.HCl		200	200	100	200	200	100	50	200
11	Hydroxyproline						50			
12	Isoleucine		200	200	100	200	300	100	125	200
13	Leucine		200	200	100	400	100	100	125	200
14	Lysine.HCl		400	400	200	400	600	200	200	400
15	Methionine		200	200	100	200	100	100	50	200
16	Norleucine						200			
17	Phenylalanine		200	200	50	200	500	50	50	200
18	Proline		200	200	50		400	50	100	400
19	Serine		200	200	50	200	100	50	25	500
20	Threonine		200	200	100	200	100	100	100	200
21	Tryptophan		200	200	100	400	50	100	20	200
22	Tyrosine		200	200	100	400	400	100	100	200
23	Valine		200	200	100	200	200	100	125	200
	Vitamins									
24	D-Biotin	0.02	0.001	0.01	0.01	0.005	0.005	0.01	0.01	0.01
25	Choline.Cl	10	5							
26	Cobalamin					0.004	0.01	0.002		
27	Folacin	0.02	0.01	0.01	0.01	0.005	0.055	0.01	0.01	0.02
28	L-Inositol	10	20							
29	Niacin	2	0.5	1	1	4	1	1	1	1
30	DL-Ca-pantothenate	4	1	1	0.5	2	1	0.5	0.5	0.5
31	Pantethine[5]					200				
32	Para-aminobenzoic acid	0.02	0.001	0.2	0.1	2	0.04	0.1	0.1	0.2
33	Pyridoxine.HCl	2	2		0.5		2	0.5	1	0.5
34	Pyridoxamine.HCl	2					0.4			0.5
35	Pyridoxal.HCl			0.2	0.5		2	0.5	0.3	
36	Pyridoxal phosphate					1	1			
37	Riboflavine	4	0.1	1	0.5	2	1	0.5	0.5	0.5
38	Thiamine.HCl	4	1	1	0.5	10	1	0.5	0.5	0.5
	Salts[6]									
39	$CaCl_2$		3			100				
40	$FeCl_3$	20								
41	$FeSO_4$		7	22	5.5	5.5	5.5	5.5	5.5	15
42	KCl	400								
43	KCN					0.25				
44	KH_2PO_4		3,120		500	500	2,000	500	600	
45	K_2HPO_4			5,000	500	500	2,000	500	600	5,000

/1/ The medium given is also suitable for L. casei, L. delbrueckii, L. fermenti, L. brevis (l-arbinose is to be substituted for glucose), and Leuconostoc mesenteriodes. /2/ The medium given is also suitable for Leuconostoc mesenteriodes strain P-60 (aspartic acid is to be substituted for asparagine), and Streptococcus fnecalis strain R. /3/ Values given are for DL-isomers. For the l-isomer forms, one-half the amount indicated is used. /4/ As cysteine hydrochloride. /5/ N-(pantothenyl)-β-aminoethane disulfide. /6/ Anhydrous salts or comparable quantity of salts incorporating water in the molecule.

61. CULTURE MEDIA: CERTAIN BACTERIA (Concluded)

Values are mg of the nutrient per liter of culture solution.

	Organism / Components	Bacillus subtilis	Hemophilus parainfluenzae	Lactobacillus arabinosus[1]	L. arabinosus strain 17-5[2]	L. lactis	L. leichmannii	L. leichmannii strains 313 and 327	Leuconostoc citrovorum strain 8081	Streptococcus faecalis
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	Salts[6] (concluded)									
46	$MgSO_4$	300	40	390	98	98	684	98	98	250
47	$MnSO_4$	15		87	21.8	6.8	203	21.8	10.9	30
48	NaCl	300		40	10	10		10	10	15
49	Na_2SO_4	4,000								
50	NH_4Cl		280	3,000					30	2,500
51	$(NH_4)_2HPO_4$	8,000								
52	$ZnCl_2$	10								
	Carbohydrates									
53	Glucose		1,000	20,000	20,000	10,000	20,000	20,000	25,000	20,000
54	Sucrose	100,000								
	Purines and Pyrimidines									
55	Adenine sulfate	40	10	10	10	10	5	10	10	10
56	Cytidylic acid						10			
57	Guanine.HCl	40	10	10	10	10	5	10	10	
58	Uracil	40	10	10	10	10	5	10	10	
59	Uridine									0.2
60	Xanthine	40		10	10	10	8	10	10	
	Other Compounds									
61	Citric acid	2,000								
62	Sodium acetate		6,000	1,000	20,000	6,000	3,600	20,000	20,000	5,000
63	Sodium citrate			20,000			5,000			5,000
64	Sodium ethyl oxalacetate					500	100			
65	Glutathione									20
66	Coenzyme I		0.1[7]							
67	Tween 80					100	1	1,000		10
68	Putrescine		500							
69	Reticulogen[8]								0.49	

/1/ The medium given is also suitable for L. casei, L. delbrueckii, L. fermenti, L. brevis (L-arbinose is to be substituted for glucose), and Leuconostoc mesenteriodes. /2/ The medium given is also suitable for Leuconostoc mesenteriodes strain P-60 (aspartic acid is to be substituted for aspargine), and Streptococcus faecalis strain R. /6/ Anhydrous salts or comparable quantity of salts incorporating water in the molecule. /7/ Added ascptically to medium. /8/ A product of Eli Lily Company. /9/ As ml per liter of medium.

62. CHEMICAL ELEMENT COMPOSITION AND NEUTRALIZING ACTION: INORGANIC FERTILIZERS

Values, with the exception of those for neutralizing action, are grams per 100 grams of air-dry fertilizer material. It should be understood that values for neutralizing action are approximate only and their validity is questionable under working conditions.

	Fertilizer Material	Elements[1]						Neutralizing Action	
		Calcium[2]	Magnesium[3]	Nitrogen[4]	Phosphorus[5]	Potassium[6]	Sulfur[7]	Acidifying Action	Alkalinizing Action
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	Units[8]	Units[9]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
	Nitrogen Materials								
1	Ammonia, anhydrous			82				148	
2	Ammonia solution[10]			20.6-24.7				37-44	
3	Ammonium chloride			24.0				128	
4	Ammonium nitrate			33-34				60	
5	Ammonium sulfate			20.5			23.6	110	
6	Calcium cyanamide[11]	39		21.0			0.4		63
7	Calcium ammonium nitrate[12]	7.1-14.3	0-4.5	20.5				0	0
8	Calcium nitrate	20.0		15.5					21
9	Calcium nitrate-urea[13]	9.3		34				28	
10	Sodium nitrate			16.0					29
11	Urea[14]			42				75	
12	Urea-ammonia liquor			46				82	
	Phosphorus Materials[15]								
13	Basic slag, Bessemer[16]	34	2.4		7.0		0.2		+[17]
14	Basic slag, open-hearth	32	3.0		2.2-6.5		0.2		+[17]
15	Phosphate rock, defluorinated[18]	20.0-30			7.9-10.5				+[17]
16	Phosphoric acid, liquid				23.6		1.4[19]	+[20]	
17	Superphosphate, double[21]	12.1-14.3	0.3		18.8-21.4		1.0[22]	0	0
18	Superphosphate, ordinary[23]	17.9-21.4	0.3		6.1-8.7		11.2-12.4	0	0
	Potassium Materials								
19	Alunite, calcined[24]	2.9	0.3			4.6	2.0		
20	Kainite	0.4-3.6	0-9.0			10.0-18.3	0.4-10.0	0	0
21	Manure salts	0-0.7	0-3.6			20.8-33	0-5.2	0	0
22	Potassium carbonate					54	0.2		+[17]
23	Potassium chloride	0-2.1	0-1.8			40-51	0-2.8	0	0

24	Potassium magnesium sulfate	0-4.6	3.6-11.8			17.4-24.9	12.8-22.4	0	0
25	Potassium sulfate	0-1.8	0-1.2			40-43	15.6-19.2	0	0
	Nitrogen-Phosphorus Materials								
26	Ammoniated superphosphate, double	11.8-13.9	0.3	4.0-6.0	18.5-21.2		1.0[22]	11-14	
27	Ammoniated superphosphate, ordinary	17.2-20.7	0.3	2.0-5.0	5.9-8.5		10.8-12.0	4-7	
28	Monoammonium phosphate[25,26]	1.1	0.3	11.0	20.9		2.4	55	
29	Monoammonium phosphate-ammonium sulfate[26,27]	0.4		16.0	8.7		15.4	86	
30	Urea-superphosphate			7.0	6.5			13	
	Nitrogen-Potassium Materials								
31	Potassium ammonium chloride[28]			13.0		18.3		70	
32	Potassium nitrate	0.4	0.3	13.0		37			23
33	Sodium potassium nitrate			15.0		12.5			26
	Nitrogen-Phosphorus-Potassium-, and Phosphorus-Potassium Materials								
34	Ammonium potassium phosphate			5.5	23.6	15.4		+[20]	
35	Monopotassium phosphate				22.8	29		0	0
36	Potassium metaphosphate	0.4			24.0	32		0	0

/1/ Data represent the total amount present, with the exception of phosphorus and potassium (cf. Fn 5,6). /2/Calcium x 1.3992 = calcium oxide, CaO./3/Magnesium x 1.6579 = magnesium oxide, MgO./4/Nitrogen x 6.0683 = sodium nitrate./5/Data applicable to available phosphorus, i.e., amount of phosphorus soluble in water or in salts or acids. Phosphorus x 2.2914 = phosphorus pentoxide, P_2O_5. /6/ Data applicable to water-soluble potassium. Potassium x 1.2046 = potassium oxide, K_2O. /7/ Sulfur x 2.4969 = sulfur trioxide, SO_3. /8/ Grams of calcium carbonate, $CaCO_3$, required to neutralize the soil acidity resulting from the use of 100 grams of the fertilizer material. /9/ Grams of calcium carbonate that correspond in acid-neutralizing power to 100 grams of the fertilizer material. That is, a material having an alkalinizing action of 63, e.g., calcium cyanamide, indicates that 100 grams of this material applied to the soil would be equivalent to 63 grams of calcium carbonate for neutralizing soil acidity. /10/ Includes ammonium hydroxide, aqua ammonia, ammonia liquor, "B" liquor. /11/ Also known as Cyanamid, lime-nitrogen, Nitrolime. /12/ Also known as A. N. L. The material is a mixture of ammonium nitrate with either precipitated calcium carbonate, ground high-calcium limestone or ground dolomitic limestone. /13/ Also known as Calurea. /14/ Also known as Uramon. Data applicable to U. S. /15/ Data for composition of phosphate rocks are not presented because responses of crop plants to application of ground phosphate rock are extremely variable. /16/ Also known as Thomas slag, Thomas phosphate, Thomas meal. /17/ The material is basic. /18/ Also known as defluorinated phosphate, fused phosphate rock, fused tricalcium phosphate, alpha-phosphate. /19/ Value applicable to the sulfuric acid process. Very little sulfur is present in phosphoric acid manufactured by the electric furnace process. /20/ The material is acidic. /21/ Also known as triple superphosphate, concentrated superphosphate. /22/ Value applicable to material prepared with phosphoric acid manufactured by the sulfuric acid process. Very little sulfur is present in material prepared with phosphoric acid manufactured by the electric furnace process. /23/ Standard or normal superphosphate. /24/ Composition varies widely. /25/ Also known as Ammo-Phos A. /26/ Data applicable to material made with phosphoric acid manufactured by the sulfuric acid process. A higher purity is found in material prepared with phosphoric acid manufactured by the electric furnace process. /27/ Also known as Ammo-Phos B. /28/ Also known as Potazote.

63. CHEMICAL ELEMENT COMPOSITION AND NEUTRALIZING ACTION: ORGANIC FERTILIZERS

Values, with the exception of those for neutralizing action, are grams per 100 grams of air-dry fertilizer material. It should be understood that although these values are regarded as typical, wide variation is to be expected in the composition. Values for neutralizing action are approximate only and their validity is questionable under working conditions.

	Fertilizer Material	Elements[1]						Neutralizing Action	
		Calcium[2]	Magnesium[3]	Nitrogen[4]	Phosphorus[5]	Potassium[6]	Sulfur[7]	Acidifying Action	Alkalinizing Action
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	Units[8]	Units[9]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
	Animal By-products								
1	Blood, dried	0.4		13.0	0.9	0.8		23	
2	Bone meal, raw	22.5	0.6	4.0	9.8		0.2		20
3	Bone meal, steamed	23.6	0.3	2.5	10.9		0.2		25
4	Fish scrap or meal, dried	6.1	0.3	9.5	3.1		0.2	5	
5	Hoof and horn meal	1.8		14.0	0.4		0.8	+10	
6	Tankage	11.1	0.3	7.0	4.4	0.4	0.4		13
7	Tankage, process	0.4		9.0	0.2		0.4	16	
8	Whale guano or tankage	6.4	0.3	9.5	2.8			4	
9	Wool waste	0.4		3.5	0.2	1.7			
	Animal Excreta								
10	Guano, bat	5.4	0.3	8.5	2.2	1.2	0.8	+10	
11	Guano, Peruvian	7.9	0.6	13.0	5.2	2.1	1.4	13	
12	Manure, cattle	2.9	0.6	2.0	0.7	1.7	0.2		+11
13	Manure, horse	1.1	0.6	2.0	0.7	1.2	0.2		+11
14	Manure, poultry	2.9	0.6	5.0	1.3	1.2	0.8	+10	
15	Manure, sheep	3.6	1.2	2.0	0.7	2.5	0.6		+11
16	Sewage sludge, activated	1.8	0.9	6.0	1.3	0.4	0.4	10	
17	Sewage sludge, dried	1.8	0.3	2.0	0.9		0.2	+10	
	Plant Residues								
18	Castor pomace	0.4	0.3	5.5	0.7	1.2		6	
19	Cocoa shell meal	1.1	0.3	2.5	0.4	1.7			2
20	Cottonseed hull, ash	6.8	3.0		2.4	22.4	1.0		55
21	Cottonseed meal	0.4	0.3	7.0	1.3	1.7	0.2	10	
22	Garbage tankage	3.2	0.3	2.5	1.3	0.8	0.4		7
23	Kelp, Pacific	1.1	0.6	2.5	0.7	12.5	1.0		
24	Linseed meal	0.4	0.6	5.5	0.9	1.2	0.4		
25	Peat, moisture-free	0.7	0.3	2.0			0.2	+12	+12
26	Seaweed, dried	2.1	0.6	1.5	0.2	1.7	1.4		
27	Soybean meal	0.4	0.3	7.0	0.7	2.1	0.2	+10	
28	Tobacco, ash	15.7	3.6		1.3	19.1			+11
29	Tobacco stems	3.6	0.3	2.0	0.2	5.0	0.4		25
30	Wood ash, commercial	23.2	2.1		0.9	4.2	0.4		+11

/1/ Data represent the total amount present. /2/ Calcium x 1.3992 = calcium oxide, CaO. /3/ Magnesium x 1.6579 = magnesium oxide, MgO. /4/ Nitrogen x 6.0683 = sodium nitrate, $NaNO_3$. /5/ Phosphorus x 2.2914 = phosphorus pentoxide, P_2O_5. /6/ Potassium x 1.2046 = potassium oxide, K_2O. /7/ Sulfur x 2.4969 = sulfur trioxide, SO_3./8/ Grams of calcium carbonate, $CaCO_3$, required to neutralize the soil acidity resulting from the use of 100 grams of the fertilizer material. /9/ Grams of calcium carbonate that correspond in acid-neutralizing power to 100 grams of the fertilizer material. That is, a material having an alkalinizing action of 20, e.g., bone meal, indicates that 100 grams of this material applied to the soil would be equivalent to 20 grams of calcium carbonate for neutralizing soil acidity. /10/ The material is acidic. /11/ The material is basic. /12/ Some peats are acidic, others basic.

64. SOIL pH REQUIREMENTS: PLANTS

Plant growth is best at the optimum pH (col. B) and only fair at the limits of the range (col. C.)

	Species	Soil pH	
		Optimum	Range[c]
	(A)	(B)	(C)
	Field and Forage Crops		
1	Alfalfa (Medicago sativa)	6.0-7.5	5.5-8.5
2	Barley (Hordeum vulgare)	6.5-7.5	5.5-8.5
3	Beet, sugar (Beta vulgaris)	6.5-8.0	5.5-8.5
4	Bluegrass, Kentucky (Poa pratensis)	5.5-7.5	
5	Buckwheat (Fagopyrum esculentum)	5.5-7.0	4.5-8.0
6	Clover, red (Trifolium pratense)	6.0-7.5	5.5-
7	Clover, white (T. repens)	5.5-7.0	5.0-
8	Cotton (Gossypium hirautum)	5.0-6.0	-8.5
9	Flax (Linum usitatissimum)	5.0-7.0	-8.5
10	Hemp (Cannabis sativa)	6.0-7.0	
11	Oats (Avena sativa)	5.0-7.5	4.5-8.0
12	Peanut (Arachis hypogaea)	5.5-6.5	-8.0
13	Redtop (Agrostis alba)	5.0-6.0	-7.0
14	Rice (Oryza sativa)	5.0-6.5	-7.0
15	Rye (Secale cereale)	5.0-7.0	4.5-8.0
16	Sorghum (Sorghum vulgare)	5.5-7.5	4.5-8.0
17	Soybean (Glycine soja)	6.0-7.0	5.5-
18	Sugar cane (Saccharum officinarum)	6.0-8.0	5.0-
19	Sunflower (Helianthus annuua)	6.0-7.5	
20	Sweetclover (Melilotus alba)	6.5-8.0	
21	Tobacco (Nicotiana tabacum)	5.5-7.5[1]	4.5-
22	Wheat (Triticum aestivum)	5.5-7.5	5.0-8.5
	Fruit and Vegetable Crops		
23	Apple (Pyrus malus)	5.0-7.0	-8.0
24	Bean, lima (Phaseolus lunatus mac.)	6.0-7.0	
25	Bean, snap and wax (P. vulgaris)	6.0-7.5	
26	Beet, garden (Beta vulgaris)	6.0-7.5	5.5-
27	Blueberry (Vaccinium spp.)	4.5-6.0	
28	Cabbage (Brassica oleracea capitata)	6.0-7.5	-8.5
29	Cantaloupe (Cucumis melo)	6.0-8.0	
30	Carrot (Daucus carota)	5.5-7.0	5.0-8.5
31	Celery (Apium graveolens dulce)	6.0-7.0	-8.5
32	Corn (Zea mays)	5.5-7.5	5.0-8.0
33	Cress, garden (Lepidium sativum)	6.0-7.0	
34	Cucumber (Cucumis sativus)	5.5-7.0	-8.0
35	Lemon (Citrus limonia)	6.0-7.5	-8.5
36	Lettuce (Lactuca sativa)	6.0-7.0	5.5-8.0
37	Onion (Allium cepa)	6.0-7.0	5.0-7.5
38	Orange, sweet (Citrus sinensis)	6.0-7.5	-8.0
39	Parsley (Petroselinum hortense)	5.0-7.0	
40	Pea, garden (Pisum sativum)	6.0-8.0	
41	Peach (Prunus persica)	6.0-7.5	-8.0
42	Pear (Pyrus communis)	6.0-7.5	-8.0
43	Pepper (Capsicum annuum)	5.5-7.0	
44	Pineapple (Ananas sativus)	5.0-6.0	-7.0
45	Potato (Solanum tuberosum)	5.0-6.5[2]	-8.0
46	Radish (Raphanus sativus)	6.0-7.0	5.0-8.0
47	Spinach (Spinacia oleracea)	6.0-7.5	-8.5
48	Squash, winter (Cucurbita maxima)	5.5-7.0	
49	Strawberry (Fragaria spp.)	5.0-6.5	4.5-8.0
50	Sweetpotato (Ipomoea batatas)	5.0-6.0	-7.5

	Species	Soil pH	
		Optimum	Range[c]
	(A)	(B)	(C)
	Fruit and Vegetable Crops (concluded)		
51	Tomato (Lycopersicon esculentum)	5.5-7.5	
52	Turnip (Brassica rapa)	5.5-7.0	
53	Watermelon (Citrullus vulgaris)	5.5-6.5	5.0-8.0
	Ornamental Shrubs and Herbaceous Plants		
54	African violet (Saintpaulia ionantha)	6.0-7.0	
55	Aster, China (Callistephus chinensis)	6.5-7.0	5.5-
56	Balsam, garden (Impatiens balsamina)	6.0-7.5	5.5-
57	Begonia (Begonia spp.)	6.0-7.0	
58	Camellia (Camellia japonica)	4.5-5.5	
59	Canna (Canna indica)	6.0-8.0	
60	Carnation (Dianthus caryophyllus)	6.0-7.5	5.0-
61	Chrysanthemum (Chrysanthemum morifolium)	6.0-7.5	5.0-8.0
62	Coleus (Coleus blumei)	6.0-7.0	
63	Dahlia (Dahlia spp.)	6.0-8.0	
64	Gardenia (Gardenia jasminoides)	5.0-7.0	
65	Geranium (Pelargonium domesticum)	6.0-8.0	5.0-
66	Gladiolus (Gladiolus spp.)	6.0-8.0	
67	Hibiscus, Chinese (Hibiscus rosa-sinensis)	6.0-8.0	
68	Holly, English (Ilex aquifolium)	5.0-7.0	
69	Hyacinth (Hyacinthus orientalis)	6.5-7.5	
70	Iris, bearded (Iris spp.)	6.0-8.0	
71	Ivy, English (Hedera helix)	6.0-8.0	
72	Kalanchoe (Kalanchoe blossfeldiana)	6.0-7.5	
73	Lily, Easter (Lilium longiflorum)	6.0-7.0	
74	Nasturtium (Tropaeolum majus)	5.5-7.5	5.0-
75	Narcissus (Narcissus spp.)	5.0-7.0	
76	Primrose, evening (Oenothera biennis)	6.0-8.0	
77	Rhododendron (Rhododendron obtusum)	4.5-6.0	
78	Rose (Rosa hybrida)	5.5-7.0	5.0-7.5
79	Snapdragon (Antirrhinum majus)	6.0-7.5	5.0-8.0
80	Spiderwort (Tradescantia virginiana)	5.0-7.5	
81	Stock (Matthiola incana)	6.0-7.5	
82	Tulip (Tulipa gesneriana)	6.0-7.0	-7.5
	Miscellaneous Trees		
83	Arborvitae (Thuja occidentalis)	6.0-7.5	5.5-8.5
84	Aspen, quaking (Populus tremuloides)	4.0-5.5	
85	Elm (Ulmus spp.)[3]	6.0-8.0	
86	Hemlock (Tsuga canadensis)	5.0-6.0	-7.0
87	Holly, American (Ilex opaca)	5.0-6.0	
88	Locust, black (Robinia pseudoacacia)	6.0-7.5	
89	Magnolia (Magnolia grandiflora)	5.0-7.0	
90	Maple, sugar (Acer saccharum)	6.0-7.5	
91	Oak (Quercus spp.)[4]	5.0-6.5	
92	Oak, white (Q. alba)	6.0-7.0	
93	Pine, longleaf (Pinus palustris)	4.5-5.0	-6.0
94	Pine, red (P. resinosa)	5.0-6.0	4.5-
95	Spruce, Sitka (Picea sitchensis)	5.0-6.0	-7.0

/1/ For disease control, 6.0. /2/ For scab control, 5.4. /3/ Species include: American elm (U. americana), Chinese elm (U. parvifolia). /4/ Species include: Chestnut oak (Q. montana), pin oak (Q. paluatris).

65. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: FOODSTUFFS OF ANIMAL ORIGIN

Values, with the exception of Calories, are in grams per 100 grams of edible portion of foodstuff, ready for cooking or ready to eat if consumed uncooked. Values of 25 and above have been rounded to the nearest whole number. For mineral and vitamin composition see table 66.

	Foodstuff \ Constituents	Energy Value[1]	Water	Total Solids[2]	Protein	Fat	Carbohydrate	Ash
		Cal/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Dairy Products							
1	Butter	716	15	85	0.6	81	0.4	2.5
2	Buttermilk, cultured	36	90	9	3.5	0.1	5.1	0.8
3	Cheese, cheddar	398	37	63	25	32	2.1	3.7
4	Cheese, cottage	95	76	24	19.5	0.5	2	1.5
5	Cheese, cream	371	51	49	9	37	2	1
6	Cheese, Swiss	370	39	61	28	28	1.7	3.8
7	Cream, light, table or coffee	204	72	28	2.9	20	4	0.6
8	Milk, cow, skimmed, pasteurized & raw	36	90	10	3.5	0.1	5.1	0.8
9	Milk, cow, whole, pasteurized & raw	68	87	13	3.5	3.9	4.9	0.7
10	Milk, goat	67	87	13	3.3	4	4.6	0.7
	Fats and Oils							
11	Lard	902	0	100	0	100	0	0
	Meats							
12	Beef, brains[3]	125	79	21	10.4	8.6	0.8	1.4
13	Chuck[4]	224	65	35	18.6	16	<0.5	0.9
14	Flank[4]	247	61	39	19.9	18	<0.5	0.9
15	Hamburger[4]	321	55	45	16	28	<0.5	0.8
16	Heart, lean	108	78	22	16.9	3.7	0.7	1.1
17	Kidney	141	75	25	15	8.1	0.9	1.1
18	Liver	136	70	30	19.7	3.2	6	1.4
19	Porterhouse[4]	296	58	42	16.4	25	<0.5	0.8
20	Rib roast[4]	282	59	41	17.4	23	<0.5	0.8
21	Round[4]	182	69	31	19.5	11	<0.5	1
22	Rump[4]	322	55	45	16.2	28	<0.5	0.8
23	Stew meat[5]	333	53	47	15.8	30	<0.5	0.7
24	Sweetbreads	344	54	46	11.8	33	<0.5	1.1
25	Tongue	207	68	32	16.4	15	0.4	0.9
26	Lamb, chop, rib[4]	356	52	48	14.9	32	<0.5	0.8
27	Heart, sheep	162	72	28	16.8	9.6	1	1
28	Kidney, sheep	105	78	22	16.6	3.3	1	1.3
29	Leg roast	235	64	36	18	17.5	<0.5	0.9
30	Liver	136	71	29	21	3.9	2.9	1.4
31	Shoulder roast[4]	295	58	42	15.6	25	<0.5	0.8
32	Pork, bacon[4]	630	20	80	9.1	65	1.1	4.3
33	Feet	271	57	43	17.0	22	<0.5	0.8
34	Ham, fresh[4]	344	53	47	15.2	31	<0.5	0.8
35	Ham, smoked[4]	389	42	58	16.9	35		5.4

/1/ Kilocalories. Digestibility losses reduce total energy from protein, fat and carbohydrates by a small amount, and loss in the urine of incompletely oxidized nitrogen products further reduces energy available from protein. Energy values have been calculated by using these factors for Calories per gram protein, fat, and carbohydrate, respectively: from milk, 4.27,8.79, and 3.87; for meat and fish, 4.27, 9.02, and 3.87; from eggs, 4.36, 9.02, and 3.68. /2/ Values rounded to nearest whole number. /3/ Data applicable to all species of edible brains. /4/ Medium fat. /5/ Also listed as "Wholesale cuts: plate and brisket, medium."

65. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: FOODSTUFFS OF ANIMAL ORIGIN (Continued)

Values, with the exception of Calories, are in grams per 100 grams of edible portion of foodstuff, ready for cooking or ready to eat if consumed uncooked. Values of 25 and above have been rounded to the nearest whole number. For mineral and vitamin composition see table 66.

	Foodstuff \ Constituents	Energy Value[1]	Water	Total Solids[2]	Protein	Fat	Carbohydrate	Ash
		Cal/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Meats (concluded)							
36	Heart	117	77	23	16.9	4.8	0.4	1.1
37	Kidney	114	77	23	16.3	4.6	0.8	1.2
38	Liver	134	72	28	19.7	4.8	1.7	1.5
39	Loin or chops, fresh	296	58	42	16.4	25	<0.5	0.9
40	Salt pork	783	8	92	3.9	85	<0.5	3.5
41	Sausage, link or bulk	450	42	58	10.8	45	<0.5	2.1
42	Spare ribs, canned	351	53	47	14.6	32	<0.5	0.8
43	Tenderloin	148	72	28	19.9	7	<0.5	1.1
44	Tongue	214	66	34	16.8	15.6	0.5	1
45	Rabbit, domesticated	135	73	27	21.0	5	0	1.1
46	Veal, chops, loin	176	69	31	19.2	11	0	1
47	Cutlet, boned (wholesale round)[4]	164	70	30	19.5	9	<0.5	1
48	Heart	133	76	24	15.4	7.1	0.8	1.2
49	Kidney	119	76	24	16.8	5.2	0.2	1.4
50	Leg roast	186	68	32	19.1	12.2	0	1
51	Liver	141	71	29	19	4.9	4	1.3
52	Stew meat, boned[4]	231	64	36	18.3	17	<0.5	0.9
53	Shoulder roast, boned (wholesale chuck)[4]	173	70	30	19.4	10	<0.5	1
54	Venison	140	73	27	20	6	0	1
	Poultry							
55	Chicken, roasters	200	66	34	20.2	12.6	<0.5	1
56	Heart	157	70	30	20.5	7	1.6	1.3
57	Liver	141	70	30	22.1	4	2.6	1.7
58	Duck, domesticated	326	54	46	16	29	<0.5	1
59	Goose, domesticated[4]	354	51	49	16.4	32	<0.5	0.9
60	Turkey[4]	268	58	42	20.1	20.2	<0.5	1
61	Liver	134	71	29	22	4.8	0.7	1.6
	Eggs: Chicken[6]							
62	Egg white	50	88	12	10.8	<0.5	0.8	0.6
63	Egg, whole	162	74	26	12.8	11.5	0.7	1
64	Egg yolk	361	49	51	16.3	32	0.7	1.7
	Fish and Shellfish							
65	Clam	81	80	20	12.8	1.4	3.4	2.1
66	Cod	74	83	17	16.5	0.4	<0.5	1.2
67	Crab, Atlantic & Pacific, hard-shell	86	80	20	16.1	1.6	0.6	1.7
68	Flounder	68	83	17	14.9	0.5	<0.5	1.3

/1/ Kilocalories. Digestibility losses reduce total energy from protein, fat and carbchydrates by a small amount, and loss in the urine of incompletely oxidized nitrogen products further reduces energy available from protein. Energy values have been calculated by using these factors for Calories per gram protein, fat, and carbohydrate, respectively: from milk, 4.27, 8.79, and 3.87; for meat and fish, 4.27, 9.02, and 3.87; from eggs, 4.36, 9.02, and 3.68. /2/Values rounded to nearest whole number. /4/ Medium fat. /6/ Fresh, frozen or stored.

65. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: FOODSTUFFS OF ANIMAL ORIGIN (Concluded)

Values, with the exception of Calories, are in grams per 100 grams of edible portion of foodstuff, ready for cooking or ready to eat if consumed uncooked. Values of 25 and above have been rounded to the nearest whole number. For mineral and vitamin composition see table 66.

	Foodstuff \ Constituents	Energy Value[1]	Water	Total Solids[2]	Protein	Fat	Carbohydrate	Ash
		Cal/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Fish and Shellfish (concluded)							
69	Haddock	79	81	19	18.2	0.1	<0.5	1.4
70	Halibut	126	75	25	18.6	5.2	<0.5	1
71	Herring, Atlantic	191	67	33	18.3	12.5	<0.5	2.7
72	Herring, Pacific	94	80	20	16.6	2.6	<0.5	1.3
73	Lobster	88	79	21	16.2	1.9	0.5	2.2
74	Oyster	84	80	20	9.8	2.1	5.6	2
75	Perch, white	113	76	24	19.3	4	0	1.2
76	Salmon, Pacific (Chinook or King)	223	63	37	17.4	16.5	<0.5	1
77	Scallops, muscle	78	80	20	14.8	0.1	3.4	1.4
78	Shrimp, fresh (without shell)							
79	Tuna, canned	198	60	40	29	8.2	<0.5	2.7
80	Whitefish, canned	156	70	30	22.9	6.5	0	1.6

/1/ Kilocalories. Digestibility losses reduce total energy from protein, fat and carbohydrates by a small amount, and loss in the urine of incompletely oxidized nitrogen products further reduces energy available from protein. Energy values have been calculated by using these factors for Calories per gram protein, fat, and carbohydrate, respectively; from milk, 4.27, 8.79, and 3.87; for meat and fish, 4.27, 9.02, and 3.87; from eggs, 4.36, 9.02, and 3.68. /2/ Values rounded to nearest whole number.

66. MINERAL AND VITAMIN COMPOSITION: FOODSTUFFS OF ANIMAL ORIGIN

Values are milligrams per 100 grams edible portion of foodstuff, ready for cooking or ready to eat if consumed uncooked. Values of 25 and above have been rounded to the nearest whole number. Imputed values, based on inadequate evidence, are enclosed in parentheses. For ash content see table 65.

	Foodstuff / Constituents	Minerals			Vitamins				
		Calcium	Iron	Phosphorus	Vit. A calc. as β-carotene[1]	Ascorbic Acid[2]	Niacin[3]	Riboflavine	Thiamine
		mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
	Dairy Products								
1	Butter	20	0	16	1.98[4]	0	0.1	0.01	Trace
2	Buttermilk, cultured	(118)	0.1	93	Trace	1	0.1	0.18	0.04
3	Cheese, cheddar	725[5]	1.0	495[5]	0.84	(0)	Trace	0.42	0.02
4	Cheese, cottage	96[6]	0.3	189[6]	(0.01)	(0)	(0.1)	0.31	0.02
5	Cheese, cream	68[7]	0.2	97[7]	(0.87)	(0)	0.1	0.22	(0.01)
6	Cheese, Swiss	925[8]	0.9	563[8]	0.87	(0)	(0.1)	(0.40)	0.01
7	Cream, light, table or coffee	97	0.1	77	0.5	1	0.1	0.14	0.03
8	Milk, cow, skimmed, pasteurized or raw	123	0.1	97	Trace	1	0.1	0.18	0.04
9	Milk, cow, whole, pasteurized or raw	118	0.1	93	(0.1)	1	0.1	0.17	0.04
10	Milk, goat	129	0.1	106	(0.1)	1	0.3	0.11	0.04
	Fats and Oils								
11	Lard	0	0	0	0	0	0	0	0
	Meat								
12	Beef, brains[9]	16	3.6	330	0	18	4.4	0.26	0.23
13	Chuck	11	2.8	167	(0)	0	4.5	0.17	0.08
14	Flank	12	3.0	186	(0)	0	4.8	0.18	0.09
15	Hamburger	9	2.4	128	(0)	0	3.8	0.14	0.07
16	Heart, lean	9	4.6	203	0.02	6	7.8	0.89	0.58
17	Kidney	9	7.9	221	0.69	13	6.4	2.55	0.37
18	Liver	7	6.6	358	26	31	13.7	3.33	0.26
19	Porterhouse	10	2.5	134	(0)	0	3.9	0.15	0.07
20	Rib roast	10	2.6	149	(0)	0	4.2	0.15	0.07
21	Round	11	2.9	180	(0)	0	4.7	0.17	0.08
22	Rump	9	2.4	131	(0)	0	3.9	0.14	0.07
23	Stew meats	9	2.4	170	0	0	4.3	0.12	0.10
24	Sweetbreads	14	1.6	596					
25	Tongue	9	2.8	187	(0)	(0)	5.0	0.29	0.12
26	Lamb, rib[10]	9	2.2	138	(0)	0	4.3	0.18	0.13
27	Heart, sheep								
28	Kidney, sheep	13	9.2	237	(0.69)	13	7.4	2.42	0.51
29	Leg roast[10]	10	2.7	213	(0)	0	5.2	0.22	0.16
30	Liver	8	12.6	364	30	33	16.9	3.28	0.40
31	Shoulder roast[10]	9	2.3	155	(0)	0	4.5	0.19	0.14
32	Pork, bacon[10]	13	0.8	108	(0)	0	1.9	0.12	0.38
33	Feet[10]	12	3.0	245	(0)	0	5.2	0.24	0.98
34	Ham, fresh[10]	9	2.3	168	(0)	0	4.0	0.18	0.74
35	Ham, smoked[10]	10	2.5	136	(0)	0	4.0	0.19	0.70
36	Heart	35	2.7	132	0.02	6	6.0	1.24	0.43
37	Kidney	11	8.0	246	0.08	13	9.8	1.74	0.58
38	Liver	10	18.0	362	8.52	23	16.7	2.98	0.40
39	Loin or chops, fresh	10	2.5	186	(0)	0	4.3	0.19	0.80
40	Salt pork	Trace	0.6	Trace[11]	(0)	0	(0.9)	(0.04)	(0.18)

/1/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity. 0.0006 mg β-carotene = 1 I. U. vitamin A. /2/ Ascorbic acid based for most part on determinations of reduced ascorbic acid. /3/ Niacin values were derived from data in the literature for nicotinic acid, nicotinamide, and other related compounds. /4/ Year-round average. /5/ Also reported: calcium 873 mg/100g, and phosphorus 610 mg/100g. /6/ Also reported: calcium 82 mg/100g, and phosphorus 263 mg/100g. /7/ Also reported: calcium 298 mg/100g, and phosphorus 208 mg/100g. /8/ Also reported: calcium 1100 mg/100g, and phosphorus 811 mg/100g. /9/ Data applicable to all species of edible brains. /10/ Medium fat. /11/ Also reported: phosphorus 42 mg/100g.

66. MINERAL AND VITAMIN COMPOSITION: FOODSTUFFS OF ANIMAL ORIGIN (Concluded)

Values are milligrams per 100 grams edible portion of foodstuff, ready for cooking or ready to eat if consumed uncooked. Values of 25 and above have been rounded to the nearest whole number. Imputed values, based on inadequate evidence, are enclosed in parentheses. For ash content see table 65.

	Foodstuff	Minerals			Vitamins				
	Constituents	Calcium	Iron	Phosphorus	Vit. A calc. as β-carotene[1]	Ascorbic Acid[2]	Niacin[3]	Riboflavine	Thiamine
		mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
	Meat (concluded)								
	Pork (concluded)								
41	Sausage, links or bulk	6	1.6	100	(0)	0	2.3	0.17	0.43
42	Spare ribs[10]	8	2.2	158	(0)	0	3.8	0.17	0.71
43	Tenderloin								
44	Tongue	29	1.4	186	(0)	(0)	(5.0)	(0.29)	0.17
45	Rabbit, domesticated	20	1.3	352			12.8	0.06	0.08
46	Veal, chops, loin	11	2.9	207	0	0	6.3	0.27	0.18
47	Cutlet, boned	11	2.9	200	(0)	0	6.5	0.26	0.14
48	Heart								
49	Kidney								
50	Leg roast	11	2.9	206	0	0	6.3	0.27	0.17
51	Liver	6	10.6	343	13.5	36	16.1	3.12	0.21
52	Stew meat, boned[10]	11	2.7	182	(0)	0	6.1	0.24	0.13
53	Shoulder roast, boned (wholesale chuck)[10]	11	2.9	199	(0)	0	6.5	0.26	0.14
54	Venison								
	Poultry								
55	Chicken, roasters	14	1.5	200	0	0	8.0	0.16	0.08
56	Heart	23	1.7	142	0.02	6	5.2	0.91	0.12
57	Liver	16	7.4	240	19.3	20	11.8	2.46	0.20
58	Duck, domesticated	15	1.8	188		(0)	5.6	0.24	0.10
59	Goose, domesticated	15	1.8	188		(0)	5.6	0.24	0.10
60	Turkey[10]	23	3.8	320		(0)	8.0	0.14	0.09
61	Liver								
	Egg, chicken[12]								
62	Egg white	6	0.2	17	(0)	0	(0.1)	0.26	0
63	Egg, whole	54	2.7	210	0.68	0	0.1	0.29	0.10
64	Egg yolk	147	7.2	586	1.93	0	Trace	0.35	0.27
	Fish and Shellfish								
65	Clam	(96)	(7.0)	(139)	0.07		(0.1)	0.18	0.10
66	Cod	10	0.4	194	0	2	2.2	0.09	0.06
67	Crab, Atlantic and Pacific, hard-shell	(39)	(0.8)	(160)			2.7	0.06	0.14
68	Flounder	12	0.8	195			1.7	0.05	0.06
69	Haddock	23	0.7	197			2.4	0.08	0.05
70	Halibut	13	0.7	211	0.26		9.2	0.06	0.07
71	Herring, Atlantic		1.1	256	0.07		3.4	0.15	0.02
72	Herring, Pacific				0.06		(2.2)	0.22	0.02
73	Lobster	61	0.6	184			(1.9)	0.06	(0.13)
74	Oyster	94	5.6	143	0.19		1.2	0.20	0.15
75	Perch, white								
76	Salmon, Pacific (Chinook or King)		(0.9)	(289)	0.19	9	7.2	0.23	0.10
77	Scallops, muscle	26	1.8	208	0		1.4	0.10	(0.04)
78	Shrimp, fresh, without shell	63	1.6	166	(0.04)	(0)	2.2	0.14	0.05
79	Tuna, canned	(8)	1.4	(351)	0.05	(0)	12.8	0.12	0.05
80	Whitefish, canned	150	0.4	263				0.09	

/1/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity. 0.0006 mg β-carotene = 1 I. U. vitamin A. /2/ Ascorbic acid based on determinations of reduced ascorbic acid. /3/ Niacin values were derived from data in the literature for nicotinic acid, nicotinamide, and other related compounds. /10/ Medium fat. /12/ Fresh, frozen or stored.

67. CHEMICAL COMPOSITION OF MILK

Values per 100 ml whole milk.

	Species	Man						Cow		Goat	
	Constituent	Colostrum[1]		Transitional Milk[2]		Mature Milk		Mature Milk			
		Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Water, g	87	83-90	86	84-90	88	82-90	87	80-92	87	81-90
2	Calories, utilizable[3]	57		63		65		65		68	
3	Total solids, g	12.8	10-17	13.6	10-16	12.4	10-17	12.7	8-20	13.4	10-19
4	Ash, g	0.33	0.2-0.7	0.24	0.1-0.4	0.21	0.1-0.5	0.72	0.3-1.2	0.77	0.4-1.1
5	Protein, g	2.7	1-21	1.6	1-3	1.2	1-3	3.3	2-6	3.3	2-5
6	Amino acids, total[4], g	1.20	0.7-4.0	0.94	0.6-1.0	1.28	0.9-1.6	3.3	2.7-4.1		
7	Casein, g	1.2	0.3-5.2	0.7	0.4-1.8	0.4	0.04-0.7	2.8	1.4-4.3	2.5	1.7-3.9
8	Lactalbumin, g			0.8		0.3	0.1-0.6	0.4	0.2-0.6	0.4	0.4-0.6
9	Lactoglobulin, g	3.5	0.4-13	0.5	0.2-1.4	0.2		0.2	0.1-0.4	0.3	
10	Whey protein, g	1.7				0.6	<0.3-1.1	0.6	0.2-1.4	1.1	0.8-2.0
11	Carbohydrate, g	5.3	1.1-7.9	6.6	4.8-8.4	7.0	4.2-9.2	4.8	2.1-6.1	4.7	3.3-6.4
12	Fat, g	2.9	0.7-12.7	3.6	0.4-9.6	3.8	0.5-9.0	3.7	0.9-9.8	4.1	1.2-8.4
13	"Essential" fatty acids, mg[5]	246				346		99		168	
14	Vitamin A, estimated total[6], mg	0.1	0.02-0.47	0.1	0.06-0.2	0.06	0.01-0.25	0.04	0.015-0.95		
15	Ascorbic acid, mg	4.4	0.4-10.4	5.4	2.7-9.0	4.3	0-11.2	1.8	.2-3.1	1.4	Trace-3.2
16	Biotin, µg	0.1	Trace-0.3	0.4	Trace-1.8	.4	Trace-.2	3.5	.2-11.	6.3	4.7-8.3
17	Choline, mg					9	5-14	13	4-28		
18	Cobalamin[7], µg	0.04	0.01-0.15	0.04	0.00-0.07	Trace		0.56	0.07-1.15	0.02	0.00-0.14
19	Vitamin D, calc. as calciferol[8], µg					.01	-0.25	0.06	.01-0.1		
20	Vitamin E, mg	1.3	.1-4	1.3	0.5-3	0.6	0.1-1	.1			
21	Folic acid group[9], µg	0.05	0.01-0.15	0.02	0.015-0.025	.2	0.1-50	.2	0.1-5	0.03	0.00-0.14
22	Inositol, mg					3	1-5	3	3-39	2	14-26
23	Vitamin K, calc as K_1[10], µg					2	0-17	8	0-33		
24	Niacin[11], µg	75	10-145	175	60-360	182	60-600	85	1 -15	213	0-320
25	Pantothenic acid, µg	183	29-302	298	135-412	196	80-584	31	45-5 8	284	130-338
26	Para-aminobenzoic acid										
27	Pyridoxine group[12], µg					11	2-22	48	3-95	7	4-13
28	Riboflavine, µg	29.6	12-50	33.2	27-44	42.	13-1	157	2 -342	114	76-150
29	Thiamine, µg	15	.5-82	6	0-26	16	<1-43	42	3 -90	48	3 -8
30	Calcium, mg	31	13-66	34	18-53	33	1 -51	12	-381	3	1 3-176
31	Chlorine, mg	91	2 -233	54	17-116	43	9-355	103	-29	159	56-260
32	Cobalt, µg							.0			
33	Copper, mg	0.05	0.02-0.6	0.05	0.04-0.07	.04	.1-0. 7	0.03	.003-0.4	0.04	0.02-0.05[13]
34	Fluorine, µg							16	-28		
35	Iodine, µg	12	4.5-5	2		7	4-9	21	0.4-18		
36	Iron, mg	.0	0.02->0.13	0.04	0.02-0. 5	.15	.02-.4	0.10	. 1-.	0.05	0.01-.07
37	Magnesium, mg	4	1-8	4	2-5	4	2-6	13	-22	16	1 -24
38	Manganese, µg	Trace				.7		2	<1-	8	-9
39	Phosphorus, mg	14	6-25	17	1 -32	15	7-35	99	58-129	106	84-161
40	Potassium, mg	74	66-87	64	53-77	55	2 -81	139	38-287	181	1 6-242
41	Silicon							Trace			
42	Sodium, mg	48	26-136	29	19-54	15	2-44	58	31-214	41	14-68
43	Sulfur, mg	22	2 -26	2	19-23	14	5-3	30	24-44	10	6-29
44	Zinc, mg	0.62	0.07-0.98	0.77	0.04->1.15	0.53	0.02->1.38	0.38	0.17-0.66	Trace	

/1/ 1st-5th day of lactation. /2/ 6th-10th day of lactation. /3/ Kilocalories, calculated on basis of "physiological fuel values" of 8.80 calories per gram of fat; 3.85 calories per gram of carbohydrate (lactose); and 4.25 calories per gram of protein. /4/ Represents only the total of values that are available. Determinations of some individual amino acids have not been reported for certain types of milk. /5/ Arachidonic, octadecadienoic acid. /6/ Milligrams of carotenoids x 0.75 ÷ (0.6 x 4.3), plus mg preformed vitamin A = estimated total vitamin A. /7/ A generic term including cyancobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /8/ 0.025 µg calciferol = one I. U. /9/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /10/ 0.083 µg vitamin K_1 = one Dam unit. /11/ The term is used here as a generic term for nicotinic acid (niacin) and nicotinic acid amide (nicotinamide); also for pellagra preventive (P. P.) factor, antiblacktongue factor. /12/ Includes pyridoxine, pyridoxal, pyridoxamine. /13/ Range of means.

68. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: FOODSTUFFS OF PLANT ORIGIN

(For minerals see page 116ff, for vitamins, page 122ff.)

Values are, with the exception of Calories, grams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Ranges represent estimate "d" (cf. Introduction) of the 95% range.

	Foodstuff \ Constituents	Energy Value[1]	Water[2]		Protein		Fat		Total Carbohydrate		Crude Fiber	Ash
		Cal/100g	g/100g		g/100g		g/100g		g/100g		g/100g	g/100g
			Value	Range[d]	Value	Range[d]	Value	Range[d]	Value	Range[d]		
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
1	Almond, dried (Amygdalus communis)	597	4.7		18.6	13.0-21.0	54.1		19.6		2.7	3.0
2	Apple (Pyrus malus)	58	84	79-91	0.3		0.4	0.3-0.5	14.9		1.0	0.3
3	Apricot (Prunus armeniaca)	51	85	82-92	1.0	0.6-1.1	0.1		12.9	12.3-13.4	0.6	0.6
4	Asparagus (Asparagus officinalis)	21	93		2.2	2.1-3.4	0.2		3.9	3.2-4.5	0.7	0.7
5	Avocado (Persea gratissima)	245	65	55-84	1.7	1.1-2.1	26.4		5.1	3.3-7.4	1.8	1.4
6	Banana (Musa paradisiaca sapientum)	88	75		1.2	1.1-1.3	0.2		23		0.6	0.8
7	Barley, pearled, dry (Hordeum vulgare)	349	11.1		8.2	7.7-12.4	1.0		78.8		0.5	0.9
8	Bean, lima, immature (Phaseolus lunatus macrocarpus)	128	67		7.5		0.8		23.5		1.5	1.7
9	Bean, lima, mature, dried (P. lunatus macrocarpus)	333	12.6		20.7		1.3		61.6		4.3	3.8
10	Bean, red kidney, mature, dried (P vulgaris)	336	12.2		23.1		1.7		59.4		3.5	3.6
11	Bean, snap, green and yellow (P. vulgaris)	35	89		2.4		0.2		7.7	6.3-14.6	1.4	0.8
12	Beet, garden, (Beta vulgaris)	42	88		1.6		0.1		9.6		0.9	1.1
13	Beet greens (B. vulgaris)	27	90		2.0		0.3		5.6		1.4	1.7
14	Blackberry (Rubus spp.)	57	85		1.2		1.0		12.5		4.2	0.5
15	Blueberry (Vaccinium corymbosum)	61	83		0.6		0.6		15.1		1.2	0.3
16	Brazil nut (Bertholletia excelsa)	646	5.3		14.4	13.8-17.0	65.9	61.5-69.4	11.0		2.1	3.4
17	Broccoli (Brassica oleracea botrytis)	29	90		3.3		0.2		5.5		1.3	1.1
18	Brussels sprouts (B. oleracea gemmifera)	47	85		4.4		0.5		8.9		1.3	1.3
19	Cabbage (B. oleracea capitata)	24	92	88-94	1.4	1.3-2.7	0.2	0.1-0.3	5.3	4.3-8.7	1.0	0.8
20	Cantaloupe (Cucumis melo cantalupensis)	20	94		0.6		0.2		4.6	4.0-9.3	0.6	0.6
21	Carrot (Daucus carota)	42	88	83-91	1.2		0.3		9.3		1.1	1.0
22	Cashew nut, roasted (Anacardium occidentale)	578	3.6		18.5		48.2		27.0	25-29	1.3	2.7
23	Cauliflower (Brassica oleracea botrytis)	25	92		2.4		0.2	0.1-0.5	4.9	4.0-6.3	0.9	0.8
24	Celery (Apium graveolens)	18	94	90-95	1.3		0.2		3.7		0.7	1.1
25	Chard, leaves and stems (Beta vulgaris)	21	92		1.4		0.2		4.4		0.9	2.2

26	Cherry, sour and sweet (Prunus spp.)	61	83	75-85	1.1	0.6-1.3	0.5		14.8	11.9-16.7	0.3	0.6
27	Coconut (Cocos nucifera)	359	47		3.4		34.7		14.0		3.2	1.0
28	Collard (Brassica acephala)	40	87		3.9		0.6		7.2		1.2	1.7
29	Corn, sweet, white and yellow (Zea mays)	92	74	69-75	3.7		1.2		20.5	19.2-21.0	0.8	0.7
30	Cranberry (Vaccinium macrocarpon)	48	87		0.4		0.7		11.3		1.4	0.2
31	Cress, water (Radicula nasturtium aquaticum)	18	94	91-97	1.7		0.3		3.3		0.5	1.1
32	Cucumber (Cucumis sativus)	12	96	95-97	0.7	0.6-0.8	0.1		2.7		0.5	0.4
33	Currant, red (Ribes rubrum)	55	84		1.2	0.7-1.6	0.2		13.6		4.0	0.6
34	Dandelion greens (Taraxacum officinale)	44	86	81-88	2.7		0.7		8.8	7.0-10.6	1.8	2.0
35	Date, dried (Phoenix dactylifera)	284	20		2.2		0.6		75.4	63.9-78.4	2.4	1.8
36	Eggplant (Solanum melongena)	24	93		1.1	0.7-1.2	0.2		5.5		0.9	0.5
37	Endive (Cichorium endivia)	20	93	91-96	1.6		0.2		4.0		0.8	0.9
38	Fig, dried (Ficus carica)	270	24		4.0		1.2		68.4		5.8	2.4
39	Fig, fresh (F. carica)	79	78	50-88	1.4		0.4		19.6		1.7	0.6
40	Gooseberry (Ribes hirtellum)	39	89		0.8		0.2		9.7	7.6-16.2	1.9	0.4
41	Grape (Vitis spp.)[3,4]	70	82		1.4		1.4		14.9	14.4-15.5	0.5	0.4
42	Grapefruit (Citrus grandis)	40	89	86-91	0.5		0.2		10.1		0.3	0.4
43	Guava (Psidium guajava)	70	81		1.0		0.6		17.1		5.5	0.7
44	Honeydew melon (Citrullus sp.)	32	91		0.5		0		8.5		0.4	0.5
45	Kale (Brassica oleracea acephala)	40	87		3.9		0.6		7.2	6.0-8.8	1.2	1.7
46	Lemon (Citrus limonia)	32	89		0.9	0.8-1.0	0.6		8.7		0.9	0.5
47	Lettuce, headed (Lactuca sativa)	15	95	91-97	1.2		0.2		2.9		0.6	0.9
48	Lime (Citrus aurantifolia)	37	86		0.8		0.1		12.3		0.9[5]	0.8
49	Mango (Mangifera indica)	66	81		0.7		0.2		17.2		1.0	0.5
50	Mushroom (Agaricus campestris)	16	91		2.4	1.8-3.5	0.3		4.0		0.9	1.1
51	Mustard greens (Brassica japonica)	22	92	87-96	2.3		0.3		4.0		0.8	1.2

/1/ Kilocalories. Values were calculated by using specific physiological energy factors, as outlined in U. S. Dept. Agr., Table of food composition for the armed forces. /2/ Values of 25 and above were rounded to nearest whole number. /3/ Data applicable to American type. /4/ European type: energy value, 66; water, 82; protein, 0.8; fat, 0.4; total carbohydrate, 16.7; crude fiber 0.5; ash, 0.5. /5/ Based on inadequate evidence.

68. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: FOODSTUFFS OF PLANT ORIGIN (Continued)

(For minerals see page 116ff, for vitamins, page 122ff.)

Values are, with the exception of Calories, grams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Ranges represent estimate "d" (cf. Introduction) of the 95% range.

	Foodstuff \ Constituents	Energy Value[1]	Water[2]		Protein		Fat		Total Carbohydrate		Crude Fiber	Ash
		Cal/100g	g/100g		g/100g		g/100g		g/100g		g/100g	g/100g
			Value	Range[d]	Value	Range[d]	Value	Range[d]	Value	Range[d]		
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
52	Oats, rolled (Avena sativa)	390	8.3		14.2		7.4		68.2		1.2	1.9
53	Okra (Hibiscus esculentus)	32	90		1.8		0.2		7.4		1.0	0.8
54	Onion, immature, green (Allium cepa)	45	88		1.0		0.2		10.6		1.8	0.6
55	Onion, mature (A. cepa)	45	88		1.4		0.2		10.3		0.8	0.6
56	Orange (Citrus spp.)	45	87	83-90	0.9		0.2		11.2	8.5-11.6	0.6	0.5
57	Parsley (Petroselinum hortense)	50	84	79-88	3.7		1.0		9.0		1.8	2.4
58	Parsnip (Pastinaca sativa)	78	79		1.5		0.5		18.2		2.2	1.2
59	Pea, garden, immature (Pisum sativum)	98	74	70-79	6.7		0.4		17.7		2.2	0.9
60	Pea, garden, mature, dried (P. sativum)	339	11.6		23.8	21.5-24.6	1.4		60.2	50-62	5.4	3.0
61	Peach (Prunus persica)	46	87	82-90	0.5		0.1		12.0		0.6	0.5
62	Peanut, roasted (Arachis hypogaea)	559	2.6		26.9	25.8-28.1	44.2	38.6-49.0	23.6	21.2-24.4	2.4	2.7
63	Pear (Pyrus communis)	63	83	76-86	0.7		0.4		15.8		1.4	0.4
64	Pecan (Carya illinoensis)	696	3.0		9.4		73.0		13.0	10.8-15.3	2.2	1.6
65	Pepper, green (Capsicum annuum)	25	92	91-94	1.2		0.2	0.1-0.3	5.7		1.4	0.5
66	Persimmon (Diospyros kaki)	78	78		0.8		0.4		20.0		1.9	0.6
67	Pineapple (Ananas sativus)	52	85	81-90	0.4	0.3-0.5	0.2		13.7		0.4	0.4
68	Plum (Prunus spp.)	50	86	74-91	0.7		0.2		12.9		0.5	0.5
69	Potato (Solanum tuberosum)	83	78		2.0		0.1		19.1	18.7-20.8	0.4	1.0
70	Prunes, dried (Prunus spp.)	268	24		2.3		0.6		71.0		1.6	2.1
71	Pumpkin (Cucurbita pepo)	31	91		1.2		0.2	0.1-2.1	7.3		1.3	0.8
72	Radish (Raphanus sativus)	20	94	87-96	1.2	1.0-1.3	0.1		4.2		0.7	1.0
73	Raisins (Vitis venifera)	268	24		2.3	1.1-2.6	0.5		71.2	64-76	0.6-1.7[6]	2.0
74	Raspberry, black (Rubus occidentalis)	74	81		1.5		1.6		15.7		6.8	0.6
75	Raspberry, red (R. strigosus)	57	84		1.2		0.4		13.8	11.6-14.4	4.7	0.5
76	Rhubarb, stems only (Rheum rhaponticum)	16	95		0.5		0.1		3.8		0.7	0.7
77	Rice, brown (Oryza sativa)	360	12.0		7.5	6.7-8.0	1.7		77.7	76-80	0.6	1.1

78	Rice, white (Oryza sativa)	362	12.3		7.6	5.9-8.0	0.3		79.4		0.2	0.4
79	Rutabaga (Brassica campestris)	38	89		1.1		0.1		8.9		1.3	0.8
80	Rye, whole grain (Secale cereale)	321	11		12.1		1.7		73.4		2.0	1.8
81	Soybeans, mature, dried (Glycine soja)	331	7.5		34.9		18.1		34.8		5.0	4.7
82	Soybean sprouts (G. soja)	46	86		6.2		1.4		5.3		0.8	0.8
83	Spinach (Spinacia oleracea)	20	93		2.3		0.3		3.2		0.6	1.5
84	Squash, summer (Cucurbita pepo)	16	95		0.6		0.1		3.9		0.5	0.4
85	Squash, winter (C. maxima)	38	89		1.5		0.3		8.8		1.4	0.8
86	Strawberry (Fragaria spp.)	37	90		0.8	0.6-1.8	0.5		8.3		1.4	0.5
87	Sweetpotato (Ipomoea batatas)	123	69		1.8	1.4-2.1	0.7		27.9		1.0	1.1
88	Tangerine (Citrus reticulata)	44	87		0.8		0.3		10.9		1.0	0.7
89	Tomato (Lycopersicon esculentum)	20	94	93-95	1.0		0.3		4.0		0.6	0.6
90	Turnip (Brassica rapa)	32	91	86-96	1.1		0.2		7.1		1.1	0.7
91	Turnip greens (B. rapa)	30	90		2.9	2.7-4.2	0.4		5.4	4.3-6.3	1.2	1.8
92	Walnut, black (Juglans nigra)	672	2.7		18.3	12.5-28	58		18.7		1.9	2.1
93	Walnut, English (J. regia)	654	3.3		15.0	12.5-18.4	64		15.6		2.1	1.7
94	Watermelon (Citrullus vulgaris)	28	92	91-93	0.5		0.2		6.9		0.6	0.3
95	Wheat, hard red winter, whole grain (Triticum vulgare)	330	12.5		12.3		1.8		71.7		2.3	1.7

/1/ Kilocalories. Values were calculated by using specific physiological energy factors, as outlined in U. S. Dept. Agr., Table of food composition for the armed forces. /2/ Values of 25 and above were rounded to nearest whole number. /6/ Estimate "d" of the 95% range.

69. MINERAL COMPOSITION: FOODSTUFFS OF PLANT ORIGIN

Values are milligrams per 100 grams of edible portion or fresh, uncooked foodstuff, unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses. Ranges represent estimate "d" (cf. Introduction) of the 95% range.

	Foodstuff / Minerals	Calcium		Chlorine	Cobalt	Copper
		mg/100g		mg/100g	mg/100g	mg/100g
		Value	Range[d]			
	(A)	(B)	(C)	(D)	(E)	(F)
1	Almond, dried (Amydalus communis)	254		2		0.14
2	Apple (Pyrus malus)	6	4-10	4-5		0.08-0.14
3	Apricot (Prunus armeniaca)	16	10-17	2	0.003	0.11-0.18
4	Asparagus (Asparagus officinalis)	21		36-39		0.14
5	Avocado (Persea gratissima)	10		6-16		0.21-0.7
6	Banana (Musa paradisiaca sapientum)	8	7-10	78-125		0.16-0.21
7	Barley, pearled, dry (Hordeum vulgare)	16		105		0.11-0.40
8	Bean, lima, immature (Phaseolus lunatus macrocarpus)	63		9		0.86
9	Bean, lima, mature, dried (P. lunatus macrocarpus	68		32-41		0.65-0.69
10	Bean, red kidney (P. vulgaris)	163				
11	Bean, snap, green and yellow (P. vulgaris)	65		24	0.01	
12	Beet, garden (Beta vulgaris)	27	24-30	58-61	0.005-0.009	0.19
13	Beet greens (B. vulgaris)	118[1]			0.04	0.09
14	Blackberry (Rubus spp.)	32	17-63	10-22		0.11-0.16
15	Blueberry (Vaccinium corymbosum)	16		8		0.11
16	Brazil nut (Bertholletia excelsa)	186		61		1.09-1.39
17	Broccoli, (Brassica oleracea botrytis)	130				
18	Brussels sprouts (B. oleracea gemmifera)	34		40		0.10
19	Cabbage (B. oleracea capitata)	46	45-50	24-39	0.007-0.024	0.05-0.06
20	Cantaloupe (Cucumis melo cantalupensis)	17	16-20	41-44		0.04-0.06
21	Carrot (Daucus carota)	39		36-67	0.002	0.07-0.08
22	Cashew nut, roasted (Anacardium occidentale)	46				
23	Cauliflower (Brassica oleracea botry.)	22		30-50		0.14
24	Celery (Apium graveolens)	50		156-183		0.01
25	Chard, leaves and stems (Beta vulgaris)	105[1]				
26	Cherry, sour and sweet (Prunus spp.)	18	16-20	<1.0	0.0005[2]	0.07-0.14
27	Coconut (Cocos nucifera)	21	13-24	114-120		0.32-0.70
28	Collard (Brassica oleracea acephala)	249				
29	Corn, sweet, white and yellow (Zea mays)	9	6-10	14	0.0002	0.06-0.08
30	Cranberry (Vaccinium macrocarpon)	14	12-20	5-9		0.09-0.14
31	Cress, water (Radicula nasturtium aquaticum)	195	157-240	61-156		0.04-0.14

/1/ Calcium may not be available because of presence of oxalic acid. /2/ Applicable to sweet cherry.

69. MINERAL COMPOSITION: FOODSTUFFS OF PLANT ORIGIN (Continued)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses. Ranges represent estimate "d" (cf. Introduction) of the 95% range.

Iodine	Iron		Magnesium	Manganese	Phosphorus		Potassium	Sodium	Sulfur	Zinc
mg/100g	mg/100g		mg/100g	mg/100g	mg/100g		mg/100g	mg/100g	mg/100g	mg/100g
	Value	Range[d]			Value	Range[d]				
(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
	4.4		257	1.94	475		690-856	3.0-5.8	145	
	0.3		5-6	0.02-0.07	10	7-12	90-116	0.2	2.9-3.7	0.04-0.16
	0.5	0.3-0.6	9-12		23	21-30	320-440	0.6-1.0	6.1	0.04
0.011	0.9	0.8-1.0	10	0.10	62		240	2.0		0.32
	0.6	0.5-1.4	29-41	4.21	38	31-50	340-396	3.0	19.4-37	
0.02	0.6	0.4-1.8	31-42	0.64-0.82	28		348-420	0.5-1.2	13.0	0.28
0.007	(2.0)		20	1.51-1.59	189		123	2.6	107	
	2.3	2.2-2.4			158		680	1.0		
	7.5			1.64-2.54	381		1300	1.0		
	6.9				437					
	1.1				44					
	1.0	0.8-2.4	23	0.54-1.35	43		350	110	17	0.93
	3.2	3.1-3.6	1138	1.26	45	40-90	570	130		0.02
	0.9	0.8-1.0	24.30	0.59	32	19-34	150-208	0.2	9.0-12.5	
	0.8	0.2-0.9	10	2.29-4.44	13	10-20	89	0.6	11	
	3.4	2.8-4.0	225-412	0.32-0.92	693		670-760	1.0-1.5	198-293	
	1.3				76					
	1.3	1.2-2.2	10.6	0.27	78		450	11.0	78	
	0.5	0.4-1.2		0.07-0.12	31	26-64	230	5.0	64-71	0.16
0.002	0.4	0.2-0.8		0.04	16	15-30	230	12	1.7	0.09
	0.8	0.4-1.0	12-17	0.06-0.25	37	21-50	224	95	6.9-17	0.11
	5.0				428		560	14		
	1.1	0.9-1.4	6.6	0.17	72		400	24	29	0.23
0.012	0.5		3-10	0.16	40	29-48	278-300	111-137	14.9	
	2.5				36					
0.33[2]	0.4		8.4[2]		20	17-31	239[2]	2.4[2]	5.9[2]	0.15[2]
	2.0	1.8-2.7	39-52	1.31	98		320	16.5-29	44-46	
	1.6				58					
0.002-0.007	0.5		38	0.15	120		240-370	0.4	32	
0.0003	0.6	0.4-1.1	8	0.30	11		65-119	1.0-1.8	7-11.3	
	2.0		17	0.54	46	10-52	314	60	127	0.56

/2/ Applicable to sweet cherry.

69. MINERAL COMPOSITION: FOODSTUFFS OF PLANT ORIGIN (Continued)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses. Ranges represent estimate "d" (cf. Introduction) of the 95% range.

	Foodstuff \ Minerals	Calcium		Chlorine	Cobalt	Copper
		mg/100g		mg/100g	mg/100g	mg/100g
		Value	Range[d]			
	(A)	(B)	(C)	(D)	(E)	(F)
32	Cucumber (Cucumis sativus)	10	6-23	24-30		0.06-0.11
33	Currant, red (Ribes rubrum)	36		14		0.11-0.12
34	Dandelion greens (Taraxacum officinale)	187	63-240	99		0.15
35	Date (Phoenix dactylifera)	72		228-290		0.21-0.38
36	Eggplant (Solanum melongena)	15		24-61		0.07-0.10
37	Endive (Cichorium endivia)	79	44-104	70-167		0.09-0.11
38	Fig, dried (Ficus carica)	186				
39	Fig, fresh (F. carica)	54		14-18	0.02	0.06-0.07
40	Gooseberry (Ribes hirtellum)	22		6-7		0.08-0.14
41	Grape (Vitis spp.)[4]	17	15-20			
42	Grapefruit (Citrus grandis)	22		1-5		0.02-0.06
43	Guava (Psidium guajava)	30				0.02
44	Honeydew melon (Citrullus sp.)	(17)				
45	Kale (Brassica oleracea acephala)	225	181-310	122		0.09
46	Lemon (Citrus limonia)	40		2-5		0.26-0.4
47	Lettuce, headed (Lactuca sativa)	22	17-43	39-74	0.005-0.023	0.04-0.15
48	Lime (Citrus aurantifolia)	(40)	15-55	39		0.97
49	Mango (Mangifera indica)	9	5-21	19		0.01
50	Mushroom (Agaricus campestris)	9		21		1.79
51	Mustard greens (Brassica japonica)	220				
52	Oats, rolled (Avena sativa)	53		73	Trace	0.23
53	Okra (Hibiscus esculentus)	82				0.12-0.20
54	Onion, immature, green (Allium cepa)	135				
55	Onion, mature (A. cepa)	32			0.013	
56	Orange (Citrus spp.)	33	24-50	3-6		0.07-0.31
57	Parsley (Petroselinum hortense)	193[1]	190-325	156		0.21-0.53
58	Parsnip (Pastinaca sativa)	57	55-60	30-41		0.10-0.12
59	Pea, garden, immature (Pisum sativum)	22	15-30	24-38	0.003	0.23-0.24
60	Pea, garden, mature, dried (P. sativum)	57		35-60		1.4
61	Peach (Prunus persica)	8		4-5		0.01-0.09
62	Peanut, roasted (Arachis hypogaea)	74		41-56		0.27-0.96
63	Pear (Pyrus communis)	13	8-20	4-11	0.018	0.10-0.21
64	Pecan (Carya illinoensis)	74		50		1.36
65	Pepper, green (Capsicum annuum)	11	6-14	13-19		0.10
66	Persimmon (Diospyros kaki)	6		2		0.41

/1/ Calcium may not be available because of presence of oxalic acid. /4/ Applicable to American and European types.

69. MINERAL COMPOSITION: FOODSTUFFS OF PLANT ORIGIN (Continued)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses. Ranges represent estimate "d" (cf. Introduction) of the 95% range.

Iodine	Iron		Magnesium	Manganese	Phosphorus		Potassium	Sodium	Sulfur	Zinc
mg/100g	mg/100g		mg/100g	mg/100g	mg/100g		mg/100g	mg/100g	mg/100g	mg/100g
	Value	Range[d]			Value	Range[d]				
(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
	0.3[3]		9	0.15	21	18-33	141-230	13	11	0.16
	0.9	0.6-1.2	13		33	18-50	160-275	2.0-2.3	29	0.20
	3.1	3.0-6.0		0.30	70		430	76		0.97
0.001	2.1	1.6-5.1	59-65	0.15	60	49-64	754-790	4.8	51	0.34
	0.4		10-15	0.11	37		190-238	0.9-2.5	9.0-9.2	
	1.7	1.2-2.8	10-13	0.22	56	38-67	381-400	10.1-18	26-32	
	3.0				111					
	0.6	0.4-0.9	20		32		190-268	1.6-2.0	12.9	0.12-0.36
0.002	0.5		7	0.04	28		210	0.7-1.9	15.9	
0.007	0.6		4	0.08-0.09	21	16-35	316	1.7-3.0	7.4	0.02-0.20
0.001	0.2		10	0.01	18	16-20	200-234	0.5-1.4	5.1-5.3	
	0.7	0.3-1.5			29	16-30				
	(0.4)				(16)					
	2.2	0.4-2.5	37	0.50-0.59	62	60-72	410	110	115	
0.07	0.6		12	0.04	22	11-30	163-360	6-9	8-12.3	0.17
0.004	0.5	0.4-0.7	10-11	0.5-1.08	25	20-42	140-208	3.1-12	11.8-12	0.18-0.47
	(0.6)				(22)					
	0.2		160		13		16			1.91
	1.0	0.7-3.1	13	0.08	115	98-136	467-520	5.0-9.1	34	0.28
0.002	2.9		27		38		450	48		
	4.5		113		405		368	33	155	
	0.7	0.6-2.0	5	0.62	62		220	1.0	14	
	0.9				24					
	0.5				44					
	0.4	0.3-0.8	10-13	0.03	23		170-197	2.9	9.0-9.2	0.17
	4.3		52	0.94	84	80-128	880-1080	28-33		
	0.7	0.5-1.1	22-29	0.03-0.34	80		342	16.5	16.5-26	
	1.9	1.7-2.1	30	0.41	122	104-130	342-370	0.5-1.0	50	
	4.7		116	2.77	388	303-411	985	38	129	
	0.6		8-11	0.11	22	18-24	160-259	0.5	5.6-7.0	0.02
	1.9		181	1.57	393	339-400	680-740	2.0-5.6	377	
	0.3	0.2-0.5	9	0.06	16	10-30	100-129	2.0-2.3	3.4-5.6	0.16
	2.4		152	3.48	324		420	0.3	5.6	
	0.4		45	0.14	25	23-30	170	0.6		
	0.3		9		26		310	0.6	5.0	

/3/ Applicable to pared cucumber; unpared contains 1.2 mg.

69. MINERAL COMPOSITION: FOODSTUFFS OF PLANT ORIGIN (Concluded)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses. Ranges represent estimate "d" (cf. Introduction) of the 95% range.

	Foodstuff \ Minerals	Calcium		Chlorine	Cobalt	Copper
		mg/100g		mg/100g	mg/100g	mg/100g
		Value	Range[d]			
	(A)	(B)	(C)	(D)	(E)	(F)
67	Pineapple (Ananas sativus)	16	8-20	29-50		0.07-0.08
68	Plum (Prunus spp.)	17	14-20	2		0.09-0.15
69	Potato (Solanum tuberosum)	11	8-14	38-79	0.006	0.14-0.17
70	Prunes (Prunus spp.)	54				
71	Pumpkin (Cucurbita pepo)	21	20-39	10-36		0.03-0.20
72	Radish (Raphanus sativus)	37	20-44	19-54		0.13-0.16
73	Raisins (Vitis venifera)	78		82		0.20-0.27
74	Raspberry, black (Rubus occidentalis)	40				
75	Raspberry, red (R. strigosus)	40	24-50	22		0.13-0.21
76	Rhubarb, stems only (Rheum rhaponticum)	51[1]				
77	Rice, brown (Oryza sativa)	39		23		0.36
78	Rice, white (O. sativa)	24		27-54	0.0006	0.06-0.19
79	Rutabaga (Brassica campestris)	55		58		0.15
80	Rye, whole grain (Secale cereale)	(38)	31-55	25-40		
81	Soybean, mature, dried (Glycine soja)	227				
82	Soybean sprouts (G. soja)	48				
83	Spinach (Spinacia oleracea)	81[1]		65-74	0.001-0.12	0.12
84	Squash, summer (Cucurbita pepo)	15				0.08
85	Squash, winter (C. maxima)	19				0.04
86	Strawberry (Fragaria spp.)	28	22-41	6-18		0.13-0.20
87	Sweetpotato (Ipomoea batatas)	30		85-94	0.002	0.15
88	Tangerine (Citrus reticulata)	(33)		2		0.09-0.11
89	Tomato (Lycopersicon esculentum)	11	7-13	34-51	0.009	0.06-0.11
90	Turnip (Brassica rapa)	40		41-70		0.07-0.09
91	Turnip greens (B. rapa)	259	216-374	168	0.003-0.107	0.09
92	Walnut, black (Juglans nigra)					
93	Walnut, English (J. regia)	83	60-90	30-40	0.005	0.31-1.0
94	Watermelon (Citrullus vulgaris)	7		8		0.07
95	Wheat, hard red winter, whole grain (Triticum vulgare)	46				

/1/ Calcium may not be available because of presence of oxalic acid.

69. MINERAL COMPOSITION: FOODSTUFFS OF PLANT ORIGIN (Concluded)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses. Ranges represent estimate "d" (cf. Introduction) of the 95% range.

Iodine	Iron		Magnesium	Manganese	Phosphorus		Potassium	Sodium	Sulfur	Zinc
mg/100g	mg/100g		mg/100g	mg/100g	mg/100g		mg/100g	mg/100g	mg/100g	mg/100g
	Value	Range[d]			Value	Range[d]				
(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
	0.3		11-17	1.07	11	8-30	210-247	0.3	2.5-2.6	0.26
0.005	0.5	0.3-0.8	8-11	0.07	20	14-32	170-195	0.6	4.6-6.4	0.03
0.004-0.009	0.7		24-27	0.10	56	40-60	410-568	0.8	34-35	0.02-0.4
	3.9				85					
	0.8	0.4-1.1	8-12	0.04	44	19-60	309-480	0.6-1.3	9.5-13	
	1.0	0.8-1.9	11-15	0.05	31		240-260	9.0	37	0.16
0.003	3.3		42	0.32	129	33-132	860	52	23	
	0.9				37					
	0.9		22	0.51	37	27-52	130-224	0.5	17.3	
	0.5				25					
0.003	2.0		119	1.70	303	290-340	150	9.0		0.3-0.9
0.003	0.8	0.5-1.1	13-28	1.08	136		113	6.3	79	1.5
	0.4			0.13	41		260	5.0		0.30
	3.7	2.7-3.9	92-155		376	352-385	412		134-146	
	8.0				586					
	1.0				67					
	3.0	2.6-4.0	55	0.70	55	40-70	780	82	27	0.62
	0.4		11	0.14	15		150-200	0.2-0.6		
	0.6		8	0.16	28		240	0.3		0.21
	0.8	0.7-0.9	12	0.06	27	23-30	161-180	0.8-1.5	13.4	0.09
	0.7		12	0.15-0.52	49	45-52	530	4.0	14.9	0.23
	(0.4)	0.3-0.6	11	0.04	(23)		110-155	2.2	10.3	0.08
0.001-0.003	0.6		11	0.14	27	21-30	230-288	2.8-3.0	10.6-10.7	0.24
	0.5	0.4-0.7	7	0.04	34	28-50	230-238	37-58	22.1	0.08
	2.4			1.42	50	49-75	440	10	54	0.21
	6.0			3.21			460	3.0		
	2.1		131-134	1.80	380	358-510	450-687	2.0-2.7	104-106	
	0.2		10	0.02-0.18	12	3-13	110	0.30	9.0	
	3.4				354					

70. VITAMIN COMPOSITION: FOODSTUFFS OF PLANT ORIGIN

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses. Ranges represent estimate "d" (cf. Introduction) of the 95% range.

	Foodstuff \ Vitamins	Vitamin A as β-carotene[1]		Ascorbic Acid		Niacin		Riboflavine		Thiamine	
		mg/100g		mg/100g		mg/100g		mg/100g		mg/100g	
		Value	Range[d]	Value	Range[d]	Value	Range[d]	Value	Range[d]	Value	Range[d]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Almond, dried (Amygdalus communis)	0		Trace		4.6		0.67		0.25	0.12-0.30
2	Apple (Pyrus malus)	0.05	0.02-0.07	5	2-20	0.2	0.1-0.5	0.03	0.01-0.05	0.04	0.01-0.06
3	Apricot (Prunus armeniaca)	1.67		7	1-11	0.8		0.05	0.04-0.11	0.03	0.02-0.05
4	Asparagus (Asparagus officinalis)	0.60	0.18-0.84	33	15-94	1.4		0.19	0.10-0.32	0.16	0.14-0.22
5	Avocado (Persea gratissima)	0.17	0.06-0.33	16	2-28	1.1		0.13	0.09-0.18	0.06	
6	Banana (Musa paradisiaca sapientum)	0.26		10	7-28	0.7		0.05	0.02-0.09	0.04	0.3-0.15
7	Barley, pearled, dry (Hordeum vulgare)	(0)		0		3.1		0.08		0.12	
8	Bean, lima, immature (Phaseolus lunatus macrocarpus)	0.17		32	15-42	1.4		0.11		0.21	
9	Bean, lima, mature, dried (P. lunatus macrocarpus)	0		2		2.0		0.18	0.14-0.32	0.48	
10	Bean, red kidney (P. vulgaris)	(0)		2		2.5		0.22		0.51	
11	Bean, snap, green and yellow (P. vulgaris)	0.38[2]	0.36-0.66	19	10-26	0.5		0.11		0.08	
12	Beet, garden (Beta vulgaris)	0.01		10	3-15	0.4	0.1-0.6	0.05	0.03-0.13	0.02	0.01-0.09
13	Beet greens (B. vulgaris)	4.02		34		0.4	0.3-0.6	0.18	0.17-0.63	0.08	0.04-0.10
14	Blackberry (Rubus spp.)	0.12	0.05-0.24	21	3-28	0.4		0.04		0.04	0.02-0.05
15	Blueberry (Vaccinium corymbosum)	0.17		16	7-22	(0.3)		(0.02)		(0.02)	
16	Brazil nut (Bertholletia excelsa)	Trace		2						0.86	0.50-1.10
17	Broccoli (Brassica oleracea botrytis)	2.10		118	50-172	1.1	0.8-1.4	0.21		0.10	
18	Brussels sprouts (B. oleracea gemmifera)	0.24	0.18-0.30	94	13-150	0.7		0.16	0.06-0.30	0.08	
19	Cabbage (B. olaracea capitata)	0.05		50	30-100	0.3	0.1-0.7	0.05	0.03-0.15	0.06	0.03-0.14
20	Cantaloupe (Cucumis melo cantalupensis)	2.05[3]		33	26-60	0.5		0.04	0.03-0.08	0.05	0.03-0.15
21	Carrot (Daucus carota)	7.20			2-10	0.5	0.2-1.5	0.06	0.04-0.09	0.06	0.03-0.14
22	Cashew nut, roasted (Anacardium occidentale)					2.1		0.19		0.63	
23	Cauliflower (Brassica oleracea botrytis)	0.05		69	37-94	0.6	0.5-0.7	0.10	0.05-0.22	0.11	0.10-0.20
24	Celery (Apium graveolens)	0		7	5-15	0.4		0.04	0.03-0.10	0.05	
25	Chard, leaves and stems (Beta vulgaris)	1.68		38		0.4		0.07		0.06	
26	Cherry, sour and sweet (Prunus spp.)	0.37	0.09-0.42	8	1-25	0.4		0.06		0.05	
27	Coconut (Cocos nucifera)	0		2		0.2		0.01		0.10	
28	Collard (Brassica oleracea acephala)	4.12		100		(2.0)		0.27		0.11	
29	Corn, sweet, white and yellow (Zea mays)	0.23[4]	0.17-0.36	12	8-43	1.7	0.7-2.6	0.12	0.05-0.14	0.15	0.12-0.19
30	Cranberry (Vaccinium macrocarpon)	0.02	0.01-0.04	12	10-15	0.1		(0.02)		(0.03)	
31	Cress, water (Radicula nasturtium aquaticum)	2.83		77	43-187	0.8		0.16	0.10-0.30	0.08	
32	Cucumber (Cucumis sativus)	0[5]		8	2-13	0.2	0.1-0.3	0.04	0-0.15	0.03	
33	Currant, red (Ribes rubrum)	0.07		36	15-45					0.04	0.03-0.05
34	Dandelion greens (Taraxacum officinale)	8.19	5.40-19.80	36	32-100	(0.8)		0.14		0.19	0.15-2.23
35	Date (Phoenix dactylifera)	8.23		(0)		2.2		0.10		0.09	0.06-0.10
36	Eggplant (Solanum melongena)	0.02	0.01-0.06	5	1-10	0.6		0.05	0.03-0.08	0.04	
37	Endive (Cichorium endivia)	1.80		11	10-27	0.4		0.12	0.06-0.24	0.07	0.06-0.09
38	Fig, dried (Ficus carica)	0.05		(0)		1.7		0.12		0.16	0.06-0.18
39	Fig, fresh (F. carica)	0.05	0.01-0.05	2		0.5		0.05		0.06	
40	Gooseberry (Ribes hirtellum)	0.17	0.07-0.23	33							0.04-0.15
41	Grape (Vitis spp.)[6]	0.05		4	2-6	0.2		0.04	0-0.05	0.06	0.02-0.07
42	Grapefruit (Citrus grandis)	Trace		40	38-43	0.2		0.02		0.04	
43	Guava (Psidium guajava)	0.15		302	60-442	1.2		0.04	0.01-0.09	0.07	0.04-0.15
44	Honeydew melon (Citrullus sp.)	0.24		23		0.2		0.03		0.05	
45	Kale (Brassica oleracea acephala)	4.52	0.45-22.2	115	50-150	2.0		0.26		0.10	
46	Lemon (Citrus limonia)	0		50	29-60	0.1		Trace		0.04	0.02-0.09
47	Lettuce, headed (Lactuca sativa)	0.32	0.04-1.32	8	6-21	0.2		0.08	0.04-0.12	0.04	
48	Lime (Citrus aurantifolia)	0		27	23-38	(0.1)		(Trace)		(0.04)	0.03-0.06

/1/Values are expressed in terms of β-carotene but include all substances having vitamin A activity. 0.0006 mg β-carotene = 1 I.U. vitamin A. /2/ Applicable to green bean; yellow bean, 0.09. /3/ Applicable to deeply colored varieties. /4/ Applicable to yellow corn; white corn, trace. /5/ Applicable to pared cucumbers; unpared, 0.16. /6/ Data applicable to both American and European types.

70. VITAMIN COMPOSITION: FOODSTUFFS OF PLANT ORIGIN (Concluded)

Values are milligrams per 100 grams of edible portion of fresh, uncooked foodstuff, unless otherwise specified. Values based on inadequate evidence are enclosed in parentheses. Ranges represent estimate "d" (cf. Introduction) of the 95% range.

	Foodstuff \ Vitamins	Vitamin A as β-carotene[1]		Ascorbic Acid		Niacin		Riboflavine		Thiamine	
		mg/100g		mg/100g		mg/100g		mg/100g		mg/100g	
		Value	Range[d]	Value	Range[d]	Value	Range[d]	Value	Range[d]	Value	Range[d]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
49	Mango (Mangifera indica)	3.81		41	25-60	0.9		0.06	0.04-0.26	0.06	0.04-0.10
50	Mushroom (Agaricus campestris)	0		5	1-8	4.9		0.44	0.01-0.50	0.10	0.06-0.20
51	Mustard greens (Brassica japonica)	3.88	0.26-7.20	102	45-180	0.8		0.20		0.09	
52	Oats, rolled (Avena sativa)	(0)		(0)		1.0		0.14		0.60	
53	Okra (Hibiscus esculentus)	0.44	0.18-1.44	30		1.1	0.7-1.1	0.07		0.08	
54	Onion, immature, green (Allium cepa)	(0.04)		24		(0.2)		(0.04)		(0.03)	
55	Onion, mature (A. cepa)	0.03		9		0.2		0.04		0.03	
56	Orange (Citrus spp.)	(0.11)	0.03-0.42	49	45-66	0.2		0.03		0.08	0.07-0.14
57	Parsley (Petroselinum hortense)	4.94	3-18	193		1.4		0.28		0.11	
58	Parsnip (Pastinaca sativa)	0		18		0.2		0.12		0.08	
59	Pea, garden, immature (Pisum sativum)	0.41	0.36-1.98	26	15-31	2.7		0.16	0.15-0.25	0.34	0.09-0.49
60	Pea, garden, mature, dried (P. sativum)	0.22		2		3.1		0.28	0.15-0.30	0.77	
61	Peach (Prunus persica)	0.53		8	7-10	0.9		0.05	0.02-0.06	0.02	0.01-0.07
62	Peanut, roasted (Arachis hypogaea)	0		(0)		16.2	12.8-36	0.13		0.30	
63	Pear (Pyrus communis)	0.01		4	3-7	0.1		0.04	0.02-0.15	0.02	
64	Pecan (Carya illinoensis)	0.03		2		0.9		0.11		0.72	
65	Pepper, green (Capsicum annuum)	0.38		120	90-180	0.4	0.2-4.9	0.07	0.04-0.18	0.04	0.02-0.07
66	Persimmon (Diospyros kaki)	1.63		11		Trace		0.05		0.05	
67	Pineapple (Ananas sativus)	0.08	0.02-0.09	24	13-30	0.2		0.02	0.01-0.08	0.08	0.05-0.13
68	Plum (Prunus spp.)	0.21	0.08-0.22	5	4-7	0.5	0.1-0.7	0.04	0.03-0.05	0.06	0.05-0.20
69	Potato (Solanum tuberosum)	0.01		17[7]	4-28	1.2	0.1-1.2	0.04	0.03-0.12	0.11	0.05-0.17
70	Prunes (Prunus spp.)	1.13	0.24-1.50	3	0-8	1.7		0.16	0.05-0.65	0.10	
71	Pumpkin (Cucurbita pepo)	(2.04)	1.20-5.52	8	3-10	(0.6)		(0.08)	0.04-0.09	(0.05)	
72	Radish (Raphanus sativus)	0.02		24	12-26	0.3		0.02		0.03	0.02-0.10
73	Raisins (Vitis venifera)	0.03	0.01-0.06	Trace		0.5	0.1-0.6	0.08	0.03-0.13	0.15	0.07-0.20
74	Raspberry, black (Rubus occidentalis)	0		(24)		(0.3)		(0.07)		0.02	
75	Raspberry, red (R. strigosus)	0.08		24	8-38	(0.3)		(0.07)		0.02	0.01-0.09
76	Rhubarb, stems only (Rheum rhaponticum)	0.02		9	6-29	0.1				0.01	
77	Rice, brown (Oryza sativa)	(0)		(0)		4.6		0.05		0.32	
78	Rice, white (O. sativa)	(0)		(0)		1.6		0.03		0.07	
79	Rutabaga (Brassica campestris)	0.20		36	20-45	0.9		0.08	0.05-0.10	0.07	
80	Rye, whole grain (Secale cereale)	(0)		(0)		1.6		0.22		0.43	
81	Soybeans, mature, dried (Glycine soja)	0.07		Trace		2.3	1.9-4.3	0.31		1.07	0.11-1.38
82	Soybean sprouts (G. soja)	0.11		13		0.8		0.20		0.23	
83	Spinach (Spinacia oleracea)	5.65	5.04-15.0	59	15-77	0.6		0.20	0.16-0.40	0.11	0.04-0.15
84	Squash, summer (Cucurbita pepo)	0.16	0.12-1.26	17	14-28	0.8		0.09	0.01-0.12	0.05	
85	Squash, winter (C. maxima)	2.97	1.20-4.20	8		0.5		0.12	0.04-0.25	0.05	
86	Strawberry (Fragaria spp.)	0.04[3]	0.03-0.72	60	25-107	0.3		0.07	0.02-0.30	0.03	
87	Sweetpotato (Ipomoea batatas)	4.62[3]		22	7-33	0.6	0.5-1.3	0.05	0.04-0.10	0.09	0.04-0.14
88	Tangerine (Citrus reticulata)	(0.25)		31	23-50	0.2[1]		(0.03)		0.07	
89	Tomato (Lycopersicon esculentum)	0.66	0.30-1.20	23	21-27	0.5		0.04		0.06	0.04-0.12
90	Turnip (Brassica rapa)	Trace		28	20-32	0.5		0.07		0.05	0.03-0.09
91	Turnip greens (B. rapa)	5.72		136	30-140	0.8	0.6-0.9	0.46	0.35-0.75	0.09	
92	Walnut, black (Juglans nigra)	0.04		0						0.33	
93	Walnut, English (J. regia)	0.02		3		1.2		0.13		0.48	0.30-0.60
94	Watermelon (Citrullus vulgaris)	0.35	0.03-0.72	6	6-8	0.2		0.05	0.01-0.07	0.05	0.03-0.06
95	Wheat, hard red winter, whole grain (Triticum vulgare)	(0)		(0)		4.3		0.12		0.52	

/1/ Values are expressed in terms of β-carotene but include all substances having vitamin A activity. 0.0006 mg β-carotene = 1 I.U. vitamin A. /3/ Applicable to deeply colored varieties. /7/ Year-round average. Recently harvested potatoes, 24; after storage of 3 mo., 12; after storage of 6 mo., 8.

71. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: TROPICAL AND SUBTROPICAL FRUITS

(For remaining columns of this table see page 126)

Values, with the exception of Calories, are grams or milligrams per 100 grams of edible portion of fresh, uncooked fruits. Ranges are estimate "c" (cf. Introduction) of the 95% range.

	Foodstuff / Constituents	Energy Value[1]		General Composition												Minerals	
				Water[2]		Protein[3]		Fat		Total Carbohydrate		Crude Fiber		Ash		Calcium	
		Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]
		Cal/100g		g/100g		g/100g		g/100g		g/100g		g/100g		g/100g		mg/100g	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
1	Avocado (Persea gratissima)	245		65		1.7	0.8-2.4	26.4		5.0	2.9-12.2	1.8	1.0-3.7	1.4	0.5-1.7	10	4-20
2	Banana (Musa paradisiece sapientum)	88	42-364	75	58-81	1.2	0.8-6.5	0.2	0-1.0	23.0	10.9-38.1	0.6	0.2-3.2	0.8	0.4-3.3	8	1-19
3	Bullocksheart (Annone reticulata)	101	66-116	72	68-79	1.7	1.2-2.5	0.6	0.1-1.1	25.2	17.0-27.5	3.4	0.9-3.7	1.0	0.3-1.1	27	10-95
4	Carambola (Averrhoa carambola)	35		90		0.7		0.5		8.0		0.9		0.4		4	
5	Cashew apple (Anacardium occidentale)	50	33-55	86	84-89	0.7	0.3-1.0	0.2	0.1-0.5	12.8	8.7-13.1	0.9	0.4-3.1	0.3		2	1-3
6	Citron (Citrus medica)			87		0.5		Trace				1.1		0.4		37	
7	Coco plum (Chrysobelanus icaco)	48	32-51	86	84-89	0.4	0.3-0.5	0.1	0-0.2	12.6	8.6-13.2	1.0	0.6-1.3	0.9	0.6-1.0	31	22-43
8	Date (Phoenix dactylifera)	284		20		2.2		0.6		75.4		2.4		1.8		72	
9	Durian (Durio zibethinus)	144		63		2.5		3.1		30.4		1.7		1.1		9	
10	Fig, fresh (Ficus carica)	79		78	87-90	1.4	1.3-2.1	0.4		19.6		1.7	1.3-2.2	0.6	0.5-0.9	54	37-78
11	Granadilla (Passiflore ligularis)	94		76	70-79	2.4	2.1-2.9	2.2	1.5-3.2	18.9		4.5	3.2-5.6	1.0		11	6-14
12	Grapefruit (Citrus grandis)	40	31-57	89	84-90	0.5	0.4-1.2	0.2	Trace-0.4	10.0	8.3-13.7	0.3	0-0.4	0.4	0.2-0.5	22	6-29
13	Guave (Psidium guajeva)	70	29-118	81	66-89	1.0	0.1-1.5	0.6	Trace-1.0	17.2	7.9-29	5.5	0.6-8.9	0.7	0.1-1.0	30	23-52
14	Jack fruit, seed (Artocerpus integrifolia)			46	42-49	5.4		0.3	0.2-0.4	46.2		1.6		2.1	1.1-3.5		
15	Lemon (Citrus limonia)	32	9-42	89	63-94	0.9	0.3-1.1	0.6	0-1.4	8.7	3.1-9.9	0.9	0-1.4	0.5	0.2-0.8	40	
16	Lime (C. aurantifolie)	37		86		0.8	0.3-1.2	0.1	Trace-0.3	12.3		0.9	Trace-1.7	0.8		40[4]	
17	Loquat (Eriobotrye jeponica)	48		87		0.4		0.2		12.4		0.5		0.5		20	
18	Lychee (Litchi chinensis)	64		82		0.9		0.3		16.4		0.3		0.5		8	
19	Mango (Mangifera indica)	66	33-90	81	78-89	0.7	0.2-2.1	0.2	Trace-1.0	17.2	9.1-20.8	1.0	0.3-2.2	0.5	0.2-0.9	9	3-37
20	Mangosteen (Garcinia mangostene)	63		83		0.6		0.6		15.6		5.1		0.2		8	
21	Manzanilla (Cretaegus pubescens)			76		0.7	0.6-0.8	0.3	0.2-0.4			2.0		0.7		83	74-91
22	More (Rubus costaricanus)			80		1.6		1.5				5.7		0.7		63	
23	Orenge, sour (Citrus aurantium)	44		88		0.7	0.8-1.0	0.1		11.2		2.0	1.8-2.2	0.5	0.4-0.7	42	33-82
24	Orange, sweet (C. sinensis)	45	16-58	87	77-93	0.9	0.3-1.7	0.2	0-0.6	11.2	4.1-13.3	0.6	0-3.7	0.5	0.3-0.6	33	4-56
25	Pepaya (Carica papaya)	39	17-56	89	86-95	0.6	0.3-1.2	0.1		10.0	4.2-12.1	0.9	0.4-2.7	0.6	0.4-1.2	20	13-41
26	Persimmon (Diospyros kaki)	78		78		0.8		0.4		20.0		1.9		0.6		6	
27	Pineapple (Ananas sativus)	52	30-82	85	78-94	0.4	0.2-0.6	0.2	Trace-0.6	13.7	8.2-20.8	0.4	0.2-0.6	0.4	0.2-3.3	16	6-57
28	Pitange (Eugenie uniflora)	51		86		0.8		0.4		12.5		0.6		0.5		9	
29	Plantain (Musa paradisiaca)	119	77-158	66	58-79	1.1	0.9-1.3	0.4	Trace-1.2	31.2	20.5-39.8	0.4	0.1-1.1	0.9	0.6-1.2	7	1-17
30	Pomegranate (Punice granetum)	63		82	74-86	0.5	0.4-1.6	0.3		16.4	12.4-20.9	0.2	0-5.3	0.5	0.3-0.8	3	

31	Prickly pear (Nopalea cochenillifera)			83		1.3		0.3				2.8		0.3		14	
32	Sapodilla (Achras zapota)	89	29-166	76	55-90	0.5	0.3-3.1	1.1	0.1-1.8	21.8	7.6-39.5	1.4	0.7-3.9	0.5	0.1-6.2	21	4-121
33	Soursop (Annona muricata)	65	49-74	82	77-84	1.0	0.2-1.7	0.3	0.1-0.8	16.3	13.1-17.0	1.1	0.8-1.8	0.7	0.4-0.9	14	
34	Spanish lime (Melicocca bijuga)	89	61-104	75	69-83	1.4	0.6-2.4	0.3	Trace-0.5	22.7	11.4-25.5	1.3	0.1-2.2	0.6	0.4-0.8	10	7-13
35	Starapple (Chrysophyllum cainito)	61	29-97	83	78-89	1.0	0.6-2.3	1.5	0.4-3.2	12.4	6.5-17.3	1.9		0.4	0.1-0.8	22	7-48
36	Sugarapple (Annona squamosa)	94		73		1.8	1.1-1.9	0.3		23.7		1.7	1.1-2.5	0.9	0.6-1.3	22	19-45
37	Tamarind (Tamarindus indica)	239		31	15-47	2.8	1.4-3.4	0.6	0.9-1.0	62.5		5.1		2.7	1.5-4.2	74	
38	Tomatillo (Physalis pubascens)			87	83-91	1.8	1.2-2.5	0.8	0.1-1.6			2.7	1.5-5.3	0.9	0.6-1.2	11	5-17
39	West Indian cherry (Malphigia punicifolia)	49	22-60	86	82-94	1.4	0.6-1.8	0.2	0.1-0.3	11.8	5.3-14.4	1.0	0.9-1.2	0.6	0.3-0.8	19	8-35
40	Zapote (Calocarpum mammosum)			63	55-73	1.6	1.2-2.1	0.5	0.2-0.8			2.1	1.4-3.1	1.2	0.9-1.6	39	28-56

/1/ Kilocalories. Calculated by protein (col. F,G) x 3.36; fat (col. H,I) x 8.37; omitting values, 16 BC and 17 BC, total carbohydrate (col. J,K) x 3.60. For lemon and lime, (lines 16,17) total carbohydrate x 2.70. /2/ Values of 25 or above are rounded to nearest whole number. /3/ Calculated by: total nitrogen x 6.25. /4/ Based on inadequate evidence.

71. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: TROPICAL AND SUBTROPICAL FRUITS (Continued)

Values, with the exception of Calories, are grams or milligrams per 100 grams of edible portion of fresh, uncooked fruits. Ranges are estimate "c" (cf. Introduction) of the 95% range.

Constituents / Foodstuff	Minerals (Concluded)				Vitamins									
	Iron		Phosphorus		Vitamin A as β-Carotene[5]		Ascorbic Acid		Niacin		Riboflavine		Thiamine	
	Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]	Value	Range[c]
	mg/100g		mg/100g		mg/100g		mg/100g		mg/100g		mg/100g		mg/100g	
(A)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)	(Z)	(BB)	(CC)	(DD)	(EE)	(FF)
1 Avocado (Persea gratissima)	0.6	0.4-2.1	38	21-64	0.17	0.03-0.48	16	5-33	1.1	0.8-2.9	0.13	0.07-2.0	0.06	0.03-0.88
2 Banana (Musa paradisiaca sapientum)	0.6	0.2-5.2	28	16-50	0.26	0-1.95	10	2-36	0.7	0.4-1.1	0.05	0.01-0.07	0.04	0.02-0.07
3 Bullocksheart (Annona reticulata)	0.8	0.4-3.6	20	8-36	Trace	0-0.02	32	15-44	0.5		0.10	0.09-0.18	0.08	0.07-0.19
4 Carambola (Averrhoa carambola)	1.5		17		0.73		35		0.3		0.02		0.04	
5 Cashew apple (Anacardium occidentale)	0.4	0.2-0.7	20	15-21	0.49	0.24-0.74	219	147-348	0.5		0.02		0.02	
6 Citron (Citrus medica)	0.6		16				37		0.1		0.03		0.05	
7 Coco plum (Chrysobalanus icaco)	0.6	0.4-0.9	17	10-20	0.01		8	5-11	0.4	0.2-0.6	0.03	0.02-0.05	0.03	0.01-0.05
8 Date (Phoenix dactylifera)	2.1		60		0.04		0		2.2		0.10		0.09	
9 Durian (Durio zibethinus)	0.9		44		0.02		24		0.7		0.20		0.24	
10 Fig, fresh (Ficus carica)	0.6		32	29-33	0.05		2		0.5		0.05		0.06	
11 Granadilla (Passiflora ligularis)	1.2	0.6-1.6	61	44-78	0.01		17	11-28	1.4	1.2-1.8	0.10	0.07-0.13	Trace	
12 Grapefruit (Citrus grandis)	0.2		18	12-48	Trace		40	23-50	0.2	0.1-0.7	0.02	0.01-0.05	0.04	0.02-0.06
13 Guava (Psidium guajava)	0.7	0.3-2.9	29	18-39	1.20		302		1.2	0.6-2.4	0.10		0.07	
14 Jack fruit, seed (Artocarpus integrifolia)														
15 Lemon (Citrus limonia)	0.6	0.3-5.8	22	7-27	0		50	19-71	0.1	Trace-0.2	Trace		0.04	0.01-0.09
16 Lime (C. aurantifolia)	0.6[4]	0.2-3.9	22[4]	9-23	0		27		0.1		Trace		0.04	0.01-0.07
17 Loquat (Eriobotrya japonica)	0.4		36		0.40		Trace							
18 Lychee (Litchi chinensis)	0.4		42				42				0.05			
19 Mango (Mangifera indica)	0.2		13	5-62	3.81		41	26-172	0.9		0.06	0.02-0.17	0.06	0.01-0.12
20 Mangosteen (Carcinia mangostana)	0.8		12				2						0.03	
21 Manzanilla (Crataegus pubescens)	2.1	1.6-2.6	16	13-18	0.32	0.11-0.54	91	90-93	0.3		0.03			Trace-0.03
22 Mora (Rubus costaricanus)			35				21		0.4		0.06		0.02	
23 Orange, sour (Citrus aurantium)	0.4	0.2-0.9	20		0.07	0.06-0.29	43		0.3	0.2-0.4	0.03		0.07	0.05-0.09
24 Orange, sweet (C. sinensis)	0.4	0.2-2.7	23	9-28	0.11[4]	0-0.24	49	37-80	0.2	0.1-0.5	0.03	0.01-0.06	0.08	0.04-0.13
25 Papaya (Carica papaya)	0.3		16	4-23	1.05	Trace-1.41	56	36-71	0.3	0.2-0.6	0.04	0.02-0.06	0.03	0.01-0.08
26 Persimmon (Diospyros kaki)	0.3		26		1.03		11		Trace		0.05		0.05	
27 Pineapple (Ananas sativus)	0.3		11	5-28	0.05	Trace-0.18	24	10-165	0.2	0.1-0.3	0.02		0.08	0.04-0.14
28 Pitange (Eugenia uniflora)	0.2		11				30							
29 Plantain (Musa paradisiaca)	0.7	0.3-4.9	30	16-79	0.01[6]	0.003-0.90	14	6-26	0.6	0.4-0.9	0.04	0.02-0.07	0.06	0.03-0.15
30 Pomegranate (Punica granatum)	0.3	0.7-1.2			0		10	4-12	0.3		0.01		0.02	Trace-0.03

31	Prickly pear (Nopalea cochenillifera)	0.3		21		Trace		17		0.3		0.03		0.01	
32	Sapodilla (Achras zapota)	0.8	0.2-3.1	12	6-38	0.04	0-1.46	14	1-40	0.2		0.02	0-0.07	Trace	0-0.03
33	Soursop (Annona muricata)	0.6	0.2-1.3	27		0.07		20	16-26	0.9	0.6-1.7	0.05	0.03-0.12	0.07	0.04-0.12
34	Spanish lime (Melicocca bijuga)	2.6	0.5-5.9	39	24-50	0.03	0.02-0.04	8	3-11	1.2	0.7-2.0	0.04	0.02-0.08	0.02	
35	Starapple (Chrysophyllum cainito)	1.4	0.3-6.6	18	13-22	0.01	0-0.04	9	3-16	1.0	0.6-1.8	0.02	0.01-0.04	0.02	0-0.07
36	Sugarapple (Annona squamosa)	0.6	0.3-1.0	41	24-55	0.01		34		1.0	0.7-1.3	0.14	0.11-0.17	0.10	
37	Tamarind (Tamarindus indica)	0.6		113		0.02		2		1.2	1.1-1.7	0.14	0.09-0.18	0.34	0.30-0.59
38	Tomatillo (Physalis pubescens)	1.0	0.6-1.3	35	25-49	0.12	0.03-0.31	8	3-12	3.5	2.0-6.8	0.04	0.03-0.06	0.12	0.08-0.21
39	West Indian cherry (Malphighia punicifolia)	1.5	1.0-2.3	26	7-33	0.02	Trace-0.04	2142	577-3309	0.5		0.07	0.06-0.09	0.02	0.01-0.03
40	Zapote (Calocarpum mammosum)	1.0	0.5-2.6	27	24-33	0.22	0.07-0.52	20	9-40	2.0	1.6-2.6	0.02	0.01-0.03	0.01	0-0.03

/4/ Based on inadequate evidence. /5/ Valuea are expressed in terms of β-carotene but include all substances having vitamin A activity. 0.0006 mg β-carotene = 1 I. U. vitamin A. /6/ Applicable to white flesh varieties; for yellow varieties, 0.72.

72. RELATIVE PRODUCTION OF NUTRIENTS: FOODSTUFFS OF PLANT ORIGIN

Data are average yields and derived values per acre (1 acre = 2.471 hectares) of land used to produce the specified food crops. Yields at retail sale (col. C) do not include an allowance for the value of by-products, (e. g., wheat used for white flour also yields bran as a by-product). Values for nutrients, calculated from col. C, represent the number of days a moderately active man can be supplied with a suitable daily allowance of the given nutrient by the yield of one acre of the foodstuff. Data for carbohydrates are not available.

	Food Product	Yield		Days of Adequate Supply of[1]									
		Quantity at Harvest	Quantity at Retail Sale[2]	Food Energy	Protein	Fat	Calcium	Iron	Vitamin A	Ascorbic Acid	Niacin	Ribo-flavine	Thiamine
		lb/acre[3]	lb/acre[3]	da	da	da	da	da	da	da	da	da	da
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
	Fresh Vegetables[4]												
1	Asparagus (Asparagus officinalis)	2,448	2,227	67	239	21	198	575	1,528	3,356	579	657	802
2	Bean, lima (Phaseolus lunatus mac.)	2,112	1,943	154	378	39	279	680	202	1,503	220	253	583
3	Bean, snap (P. vulgaris)	2,700	2,403	138	336	26	799	901	1,230	2,531	401	493	513
4	Beet, garden (Beta vulgaris)	9,516	8,565	442	661	34	985	2,426	137	3,882	799	728	628
5	Cabbage (Brassica oleracea cap.)	13,840	11,764	373	773	110	2,235	1,662	635	27,135	706	1,236	1,804
6	Cantaloupe (Cucumis melo cantal.)	6,660	5,661	90	105	30	255	424	8,254	5,208	642	227	452
7	Carrot (Daucus carota)	16,350	14,715	878	1,009	235	2,869	3,924	141,265	4,709	1,962	1,914	2,649
8	Cauliflower (Brassica oleracea bot.)	10,804	9,291	195	650	50	523	1,703	371	17,468	743	1,022	1,301
9	Celery (Apium graveolens)	27,300	24,570	516	1,299	197	4,392	2,867	0	6,552	1,474	1,474	1,474
10	Corn, sweet (Zea mays)	3,491	3,002	187	274	84	60	226	409	801	480	360	541
11	Cucumber (Cucumis sativus)	5,136	4,417	68	139	18	177	368	0	1,590	147	619	353
12	Eggplant (Solanum melongena)	7,590	6,603	245	406	71	487	880	132	1,673	1,409	726	1,189
13	Kale (Brassica oleracea acephala)	6,876	5,570	267	899	127	4,560	2,971	24,450	24,877	891	2,813	1,300
14	Lettuce (Lactuca sativa)	10,710	8,675	165	471	70	748	1,157	2,967	2,776	289	911	1,157
15	Onion (Allium cepa)	12,900	11,094	769	951	133	1,900	1,942	466	5,621	444	555	1,110
16	Pea, garden (Pisum sativum)	2,610	2,479	170	486	27	140	806	690	1,786	694	459	1,190
17	Pepper, green (Capsicum annuum)	5,650	5,086	190	334	55	267	635	2,451	30,984	474	433	916
18	Spinach (Spinacia oleracea)	3,816	3,091	95	380	45	1,163	2,885	21,661	9,025	536	1,391	907
19	Tomato (Lycopersicon esculentum)	6,201	4,650	141	266	74	255	930	4,074	5,767	775	372	744
20	Watermelon (Citrullus vulgaris)	6,975	6,068	132	87	33	114	202	1,505	1,052	162	334	404
	Canned Vegetables[4]												
21	Asparagus (Asparagus officinalis)	2,360	1,615	51	168	30	184	605	888	1,442	398	315	312
22	Bean, lima (Phaseolus lunatus mac.)	1,116	1,590	174	393	30	245	1,020	188	763	233	175	169
23	Bean, snap (P. vulgaris)	3,340	4,523	132	291	0	695	2,411	1,701	1,086	452	498	422
24	Beet, garden (Beta vulgaris)	14,120	4,688	275	301	0	398	1,055	75	1,313	157	305	156
25	Cabbage (Brassica oleracea cap.)	16,840	12,967	389	926	155	3,387	2,485	130	13,832	865	5,900	1,210
26	Corn, sweet (Zea mays)	4,680	1,756	204	229	54	40	336	323	561	445	185	129
27	Pea, garden (Pisum sativum)	1,790	2,551	265	561	62	364	1,742	1,260	1,326	697	332	816
28	Spinach (Spinacia oleracea)	4,580	4,946	185	735	118	2,528	3,009	30,500	4,353	462	940	296
29	Tomato (Lycopersicon esculentum)	10,220	4,476	144	288	53	279	1,007	4,271	4,476	954	336	686

	Fresh Fruits[5]												
30	Apple (Pyrus malus)	5,184	4,666	401	80	100	140	467	336	1,120	311	186	467
31	Apricot (Prunus armeniaca)	6,192	5,635	453	346	30	479	986	13,444	1,127	1,202	479	489
32	Avocado (Persea gratissima)	2,176	1,980	595	164	2,371	84	330	384	1,426	488	505	555
33	Blueberry (Vaccinium corymbosum)	916	888	92	34	32	81	267	229	877	77	134	71
34	Grape (Vitis spp.)	8,009	7,208	778	360	173	676	1,562	476	1,634	913	432	1,153
35	Grapefruit (Citrus grandis)	21,390	20,320	901	435	163	1,295	1,524	284	32,784	813	610	1,490
36	Lemon, (C. limonia)	18,240	17,328	710	619	393	845	433	0	29,342	462	86	1,502
37	Lime (C. aurantifolia)	2,640	2,508	154	100	10	150	63	0	3,143	84	25	267
38	Orange (C. spp.)	14,800	14,060	769	582	131	1,898	1,523	1,743	30,370	750	562	2,343
39	Peach (Prunus persica)	5,760	5,126	349	146	27	205	1,025	3,619	2,119	1,230	487	273
40	Pear (Pyrus communis)	8,700	7,830	684	291	157	480	718	141	1,670	261	626	417
41	Plum (Prunus spp.)	5,600	4,984	402	214	60	455	914	1,505	1,329	797	324	2,093
42	Strawberry (Fragaria spp.)	2,241	2,017	120	101	70	308	588	101	7,019	175	292	175
	Dried Fruits[5]												
43	Apple,nuggets (Pyrus malus)	5,184	518	306	47	31	71	804	0	346	79	90	83
44	Apricot (Prunus armeniaca)	6,192	1,207	533	407	29	589	2,234	8,145	918	1,207	428	48
45	Prune (P. spp.)	5,600	2,240	861	285	69	582	2,800	3,270	329	986	717	567
46	Raisin (Vitis spp.)	8,009	2,002	904	297	61	886	2,503	92	0	294	370	921
	Nuts[5]												
47	Almond (Amygdalus communis)	516	464	230	287	777	342	395	0	0	328	360	177
48	Pecan (Carya pecan)	128	102	60	32	235	22	49	2	5	14	14	115
49	Walnut (Juglans spp.)	912	730	348	319	1,278	154	261	10	58	117	98	477
	Grain[6]												
50	Barley, pearl (Hordeum vulgare)	1,166	642	347	341	39	59	486	0	0	604	119	235
51	Buckwheat, flour (Fagopyrum esculentum)	870	487	261	198	32	31	183	0	0	309	87	458
52	Corn, yellow, meal (Zea mays)	1,837	1,312	725	773	294	136	1,344	611	0	813	492	1,784
53	Oats, oatmeal (Avena sativa)	1,040	428	257	395	191	132	842	0	0	148	135	711
54	Rice, brown (Oryza sativa)	2,007	1,585	855	772	163	351	3,303	0	0	2,188	174	1,406
55	Rice, white (O. sativa)	2,007	1,325	704	654	24	68	353	0	0	557	79	212

/1/ Computed by dividing nutrient content of food at retail (col. C) by daily allowances of food nutrients for a moderately active man, as recommended by the National Research Council. /2/ Determined as recommended by U. S. Dept. Agr., Conversion factors and weights and measures for agricultural commodities and their products, 1944. No allowance is made for loss in nutrient content of food after it leaves retail stores or from waste in home preparation. /3/ Pounds per acre x 0.18356 = Kg per hectare. /4/ U. S. average yields from 1936-1945. /5/ U. S. average yields from unspecified period. /6/ U. S. average yields from 1941-1945.

72. RELATIVE PRODUCTION OF NUTRIENTS: FOODSTUFFS OF PLANT ORIGIN (Concluded)

Data are average yields and derived values per acre (1 acre = 2.471 hectares) of land used to produce the specified food crops. Yields at retail sale (col. C) do not include an allowance for the value of by-products, (e. g., wheat used for white flour also yields bran as a by-product). Values for nutrients, calculated from col. C, represent the number of days a moderately active man can be supplied with a suitable daily allowance of the given nutrient by the yield of one acre of the foodstuff. Data for carbohydrates are not available.

	Food Product	Yield		Days of Adequate Supply of[1]									
		Quantity at Harvest	Quantity at Retail Sale[2]	Food Energy	Protein	Fat	Calcium	Iron	Vitamin A	Ascorbic Acid	Niacin	Ribo-flavine	Thiamine
		lb/acre[3]	lb/acre[3]	da	da	da	da	da	da	da	da	da	da
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
	Grain [6]												
56	Rye, light flour (Secale cereale)	706	537	291	309	30	55	264	0	0	147	84	244
57	Rye, whole flour (S. cereale)	706	668	364	485	69	231	1,212	0	0	352	313	948
58	Wheat, white flour (Triticum vulgare)	1,062	754	405	527	41	81	189	0	0	176	57	151
59	Wheat, whole flour (T. vulgare)	1,062	1,041	566	877	126	225	1,500	0	0	1,756	291	1,756
	Other Staple Crops[6]												
60	Bean, dried (Phaseolus spp.)	889	782	414	1,116	71	656	3,050	0	83	500	419	1,413
61	Beet, brown sugar, (Beta vulgaris)	24,800	3,894	2,249	0	0	1,673	3,823	0	0	0	0	0
62	Beet, granulated sugar, (B.vulgaris)	24,800	3,646	2,199	0	0	0	145	0	0	0	0	0
63	Pea, garden, dried (Pisum sativum)	1,322	1,124	602	1,785	67	465	2,548	378	141	1,034	731	2,953
64	Peanut butter (Arachis hypogaea)	668	381	355	643	1,099	160	272	0	0	1,862	136	225
65	Potato (Solanum tuberosum)	8,328	7,445	806	812	43	391	1,674	104	6,404	2,183	561	1,985
66	Soybean (Glycine soja)	1,092	983	521	2,224	1,078	1,267	2,973	96	0	618	688	3,394
67	Sweetpotato (Ipomoea batatas)	4,912	4,224	687	421	151	620	949	25,369	4,846	789	486	1,041
68	Sugarcane, brown sugar (Saccharum officinarum)	41,200	3,317	1,923	0	0	1,442	3,262	0	0	0	0	0
69	Sugarcane, granulated sugar (S. officinarum)	41,200	3,098	1,868	0	0	0	137	0	0	0	0	0

/1/ Computed by dividing nutrient content of food at retail (col. C) by daily allowances of food nutrients for a moderately active man, as recommended by the National Research Council. /2/ Determined as recommended by U. S. Dept. Agr., Conversion factors and weights and measures for agricultural commodities and their products, 1944. No allowance is made for loss in nutrient content of food after it leaves retail stores or from waste in home preparation. /3/ Pounds per acre x 0.18356 = Kg per hectare. /6/ U. S. average yields from 1941-1945.

73. AMINO ACID COMPOSITION: CERTAIN PROTEIN FOODS

This table presents the best average values obtained from a study of the reports of analyses from 11 laboratories. The foodstuffs for analysis were prepared by a central source, and uniform samples of acid and alkaline hydrolysates and of the dried foods were distributed to the cooperating laboratories. All values are in terms of mg amino acid per 100 mg nitrogen present in the purified protein.

	Amino Acid	Beef Muscle[1]	Casein[2]	Egg Albumin[3]	Egg Powder[4]	Peanut Flour[5]	Wheat Gluten[6]
		mg/100 mg N	mg/100 mg N	mg/100 mg N	mg/100 mg N	mg/100 mg N	mg/100 mg N
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Arginine	40.2	24.4	37.4	38.9	70.5	23.0
2	Aspartic acid	58.4	45.5	68.7	67.3	81.1	23.6
3	Cystine	8.4	2.5	18.6	14.3	9.0	14.8
4	Glutamic acid	91.5	139.9	80.6	78.5	114.5	218.7
5	Glycine	35.2	12.4	23.5	24.7	33.6	20.7
6	Histidine	20.3	19.0	15.1	13.2	13.9	12.4
7	Isoleucine	32.3	39.7	40.3	38.6	25.9	28.4
8	Leucine	48.8	62.6	54.8	56.4	44.2	45.0
9	Lysine	53.7	50.6	45.0	38.3	21.8	12.6
10	Methionine	16.9	20.3	26.0	20.1	5.2	10.4
11	Phenylalanine	24.3	33.8	37.1	35.3	30.7	31.5
12	Proline	32.1	83.5	26.8	28.0	31.0	88.3
13	Threonine	27.8	28.1	30.5	30.9	17.4	17.5
14	Tryptophan	6.3	6.0	7.2	7.1	4.9	4.8
15	Tyrosine	18.5	32.2	20.8	22.1	18.1	17.4
16	Valine	32.1	46.0	46.6	43.7	28.5	26.6

/1/ Utility grade beef trimmed free from fat, ground vacuum-dried, defatted with benzol, vacuum-dried again and powdered; contains 15.97% N, on ash and moisture-free basis. /2/ Purified from acid-precipitated casein, dried in air at 60-70° C, and powdered; contains 15.23% N, on ash and moisture-free basis. No alcohol or other organic solvents used in purification process. /3/ Egg white cultured to remove natural sugar, dried at about 60° C, and powdered; contains 14.21% N, on ash and moisture-free basis. /4/ Whole fresh eggs defatted with ethylene dichloride, dried and powdered; contains 13.96% N, on ash and moisture-free basis. /5/ Spanish peanuts dried with strict temperature and moisture controls, and powdered; contains 10.51% N, on ash and moisture-free basis. /6/ Wheat gum gluten flour washed several times with cold water, vacuum-dried and powdered; contains 14.34% N, on ash and moisture-free basis.

74. PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF ANIMAL ORIGIN

Values are grams or Calories per 100 grams of feedstuff as fed. For mineral and vitamin composition see page 133.

	Feedstuff	Water	Dry Matter	Total Nutrients: Crude Protein[2]	Crude Fat[3]	Total Carbohydrate[4]: Crude Fiber	Total Carbohydrate[4]: N-Free Extract	Ash	Digested(-ible) Nutrients[1]: Protein	Fat	Total Carbohydrate[4]: Fiber	Total Carbohydrate[4]: N-Free Extract	"Total Digestible Nutrients"[5]	Digested (-ible) Calories[6]	Metabolizable Calories[7]
		g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	Cal/100g	Cal/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
1	Blood flour	7.8	92.2	84.7	1.0	1.1	0.7	4.7	81.3				82.4	361	330
2	Blood meal	8.2	91.8	84.5	1.1	1.0	0.7	4.5	60.0[8]	0.4[9]	0.2	0.2[10]	72.2	339	289
3	Bone meal, raw	6.4	93.6	26.0	5.0	1.0	2.5	59.1	17.7	5.9[11]	0	0	10.2	45	41
4	Bone meal, steamed	3.7	96.3	7.1	3.3	0.8	3.8	81.3					15[12]	66	60[12]
5	Buttermilk, dried	7.6	92.4	32.4	6.4	0.3	43.3	10.0	29.2[13]	6.3[14]	0	40.7[15]	85.3[16]	390	340
6	Crab meal	7.9	92.1	31.5	2.2	10.5	6.0	41.9	25.5				29.6	130	118
7	Fish meal, 63% protein	6.9	93.1	60.9	8.1	0.8	3.5	19.8	54.8[17]				74.2[18,19]	325	297[20]
8	Fish meal, menhaden	6.4	93.6	62.2	8.5	0.7	4.2	18.0	50.2	9.2[21]	0	0	70.9	369	284
9	Fish meal, sardine	6.9	93.1	67.2	5.0	0.6	5.4	14.9	55.1	5.0			68.9	302	276
10	Fish meal, white fish	9.6	90.4	63.0	6.7	0.1	0.1	20.5	58.6	6.0	0	0	72.2	387	289
11	Meat scrap, 52% protein	6.9	93.1	52.9	7.3	2.2	4.3	26.4	43.4[22]				61.5[23]	269	246
12	Meat & bone scrap, 50% protein	6.4	93.6	50.6	10.0	2.0	2.0	29.0	41.5				64.3[24]	282	257[25]
13	Milk, cow's	87.2	12.8	3.5	3.7	0	4.9	0.7	3.2[26]	3.7[21,27]	0	4.9[21,28]	16.6	73	66
14	Milk, skimmed, dried	5.8	94.2	34.7	1.2	0.2	50.3	7.8	31.2[29]	1.2[21,30]	0	46.8[31]	80.7[32,33]	379	323[34]
15	Tankage digester, 50% protein	6.5	93.5	51.3	11.5	2.3	2.3	26.1	43.6				66.4	291	266
16	Tankage digester, 55% protein	5.9	94.1	56.0	10.2	2.3	2.2	23.4	47.6				67.9	297	272
17	Tankage digester, 60% protein	7.9	92.1	60.6	8.5	2.0	1.8	20.2	51.5	7.2	0.1	0.3	68.4[35]	360	274[36]
18	Whey, dried	6.5	93.5	12.2	0.8	0.2	70.4	9.9	11.0				78.3[37]	343	313[38]

/1/ Quantity ingested minus quantity in feces, i. e., disappears from alimentary canal. Values are for ruminants and horses except as otherwise specified. /2/ Obtained by multiplying total nitrogen by a factor, usually 6.25. /3/ Ether extract of finely ground feedstuff material. /4/ Includes fiber (cellulose, lignin) and N-free extract (remainder of carbohydrate, organic acids). /5/ "Total digestible nutrients" (TDN), as commonly calculated, = 1 x col. I + 2.25 x col. J + 1 x col. K + 1 x col. L. /6/ Feed Calories minus fecal Calories, i. e., virtually absorbed Calories before subtraction of urinary loss. Factors used are: protein (col. I) x 5.65; fat (col. J) x 9.3; carbohydrate (col. K,L) x 4.1. Where data on individual digested(-ible) nutrients (col. I-L) are not available, feed calories are calculated as TDN x 4.38 (B. H. Schneider). /7/ Net physiological Calories available for heat, activity and growth. Metabolizable energy = bomb calorimeter energy content of feedstuff minus energy lost in gases produced by fermentation in rumen (chiefly methane), energy lost in feces and energy lost in urine. Factor used is: TDN (col. M) x 4.0. Another factor proposed for use with TDN is 3.6 (H. H. Mitchell). /8/ Chicken 74.4. /9/ Chicken, 1.0. /10/ Chicken, 0.5. /11/ The physiological effects of some feedstuffs tend to greatly stimulate the excretion of metabolizable products such as nitrogen or fat, and the digestibility of the basal ration is adversely affected. The negative sign, therefore, indicates the net negative contribution to the economy of the animal. /12/ For swine. /13/ Chicken, 26.6. /14/ Chicken, 5. /15/ Chicken, 35.1. /16/ Chicken, 72./17/ Chicken: protein, 55.4; fat, 7.6. /18/ Swine, 73. /19/ Chicken, 72. /20/ Swine, 292. /21/ The physiological effects of some feedstuffs tend to greatly increase the digestibility of one or more nutrients to an amount of 100% or more. /22/ Chicken: protein, 47.6; fat, 6.8. /23/ Chicken, 70. /24/ Swine, 67. /25/ Swine, 268. /26/ Chicken, 3.3. /27/ Chicken, 3.7. /28/ Chicken, 4.9. /29/ Chicken, 31. /30/ Chicken, 1.1. /31/ Chicken, 42.8. /32/ Swine, 86. /33/ Chicken, 76. /34/ Swine, 344. /35/ Swine, 71. /36/ Swine, 284. /37/ Swine, 83. /38/ Swine, 332.

75. MINERAL AND VITAMIN COMPOSITION: FEEDSTUFFS OF ANIMAL ORIGIN

Values are milligrams or grams per 100 grams of feedstuff as fed.

	Feedstuff \ Constituents	Minerals					Vitamins				
		Calcium	Copper	Iron	Manganese	Phosphorus	Vitamin A as β-Carotene[1]	Niacin	Pantothenic Acid	Riboflavine	Thiamine
		g/100g	mg/100g	mg/100g[2]	mg/100g	g/100g	mg/100g	mg/100g	mg/100g	mg/100g	mg/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Blood flour	0.64	0.90	295	0.64	0.48		2.91	0.55	0.64	0.04
2	Blood meal	0.30	1.00	421	0	0.21		0.31	0.11	2.70	
3	Bone meal, raw	21.72	1.87	44	0.42	10.01		0.42	0.22	0.11	0.02
4	Bone meal, steamed	29.30	1.98	88	1.12	15.10		0.44	0.18	0.08	0.20
5	Buttermilk, dried	1.35			0.33	0.94		0.62	2.97	3.48	0.37
6	Crab meal	14.50	3.39	810	5.99	1.50			0.66	0.51	
7	Fish meal, 63% protein	5.70				3.30					
8	Fish meal, menhaden	5.00	0.86	57	2.20	3.40		5.73		0.53	0.04
9	Fish meal, sardine	4.21	2.02	30	2.27	2.54		5.73	0.29	0.55	0.04
10	Fish meal, white fish	6.76			1.10	3.69		7.92		0.88	0.09
11	Meat scrap, 52% protein	8.70	1.21	50	0.88	4.40		5.96	0.46	0.53	0.007
12	Meat & bone scrap, 50% protein	9.70			1.17	4.20		4.71	0.33	0.46	
13	Milk, cow's	0.12			0.004	0.09	0.09	0.18	0.29	0.18	0.04
14	Milk, skimmed, dried	1.27	1.15	5.4	0.26	1.10		1.25	3.52	2.20	0.33
15	Tankage digester, 50% protein	10.97				5.14					
16	Tankage digester, 55% protein	7.90	2.00	152	0.70	4.30		2.88	0.15	0.15	0
17	Tankage digester, 60% protein	5.60	4.38	231	2.22	2.80		4.03	0.24	0.24	0.03
18	Whey, dried	0.91	5.33	21.2	0.24	0.75		1.12	4.93	2.86	0.40

/1/ 0.0006 mg β-carotene = 1 I. U. vitamin A. /2/ Values of 25 and above are rounded to the nearest whole number.

76. PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF PLANT ORIGIN

Values are grams or Calories per 100 grams of feedstuff as fed. For mineral and vitamin composition, see page 138ff.

Feedstuff \ Constituents	Water	Dry Matter	Total Nutrients: Crude Protein[2]	Crude Fat[3]	Total Carbohydrate[4]: Crude Fiber	Total Carbohydrate[4]: N-Free Extract	Ash	Digested(ible) Nutrients[1]: Protein	Fat	Total Carbohydrate[4]: Fiber	Total Carbohydrate[4]: N-Free Extract	"Total Digestible Nutrients"[5]	Digested(-ible) Calories[6]	Metabolizable Calories[7]
	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	Cal/100g	Cal/100g
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
Concentrates														
1 Alfalfa meal, dehydrated, 17% protein	6.7	93.3	17.8	2.8	24.2	39.7	8.8							
2 Alfalfa meal, dehydrated, 20% protein	7.1	92.9	20.9	2.9	19.8	38.2	11.1	14.4	0.9	8.5	26.0	50.5[8]	231	202[9]
3 Alfalfa meal, sun-cured, 17% protein	7.8	92.2	17.6	2.0	23.8	38.9	9.9							
4 Barley, excluding Pacific coast	10.6	89.4	12.7	1.9	5.4	66.6	2.8	10.0[10]	1.5[11]	3.0[12]	61.3[13]	77.7[14]	334	311[15]
5 Barley, Pacific coast	11.0	89.0	9.7	2.2	6.2	68.7	2.2	7.7	1.8	3.5	63.2	78.3[14]	334	313[15]
6 Beet pulp, molasses, dried	8.1	91.9	10.7	0.7	16.0	59.4	5.1	7.1	0.6	12.6	53.5	74.6	317	298
7 Brewers' dried yeast	6.3	93.7	46.8	1.2	2.8	35.7	7.2	40.2				71.7	314	287
8 Brewers' grains, dried, 25% protein	7.1	92.9	27.6	6.5	14.3	40.9	3.6	20.4[16]	5.7[17]	6.6	24.9[18]	65.5	297	262
9 Citrus pulp, dried	9.9	90.1	5.9	3.1	11.5	62.7	6.9	3.9	1.2	8.4	58.9	74.0	309	296
10 Corn and cob meal (corn ears ground)	13.9	86.1	7.3	3.2	8.0	66.3	1.3	5.3				73.3	321	293
11 Corn, dent, yellow	15.0	85.0	8.9	3.9	2.0	68.9	1.3	6.8[19]	3.5[20]	1.1[21]	64.1[22]	80.0[23]	338	320[24]
12 Corn gluten feed, 25% protein	8.9	91.1	26.6	3.0	7.2	48.2	6.1	22.9				76.5	335	306
13 Corn gluten meal, 41% protein	8.6	91.4	42.9	2.0	3.9	40.1	2.5	36.5	1.9	2.3	37.3	80.2	386	321
14 Cottonseed hulls	15.7	84.3	4.1	0.9	47.6	35.3	2.7	-0.6[25]	0.7	24.3	18.0	42.3	177	169
15 Cottonseed meal, 41% protein	7.8	92.2	41.2	6.2	11.2	27.7	5.9	33.8	5.8	3.1	19.7	69.7[26]	338	279[27]
16 Distillers' dried corn grains	7.1	92.9	28.3	8.8	11.4	41.9	2.5	20.7	8.5	9.5	33.1	82.4	371	330
17 Distillers' dried corn grains, with solubles	6.9	93.1	28.8	8.9	9.0	41.7	4.7	21.0				80.9	354	324
18 Distillers'dried solubles	6.9	93.1	28.0	6.7	3.3	47.6	7.5	20.4				75.4[28]	330	302[29]
19 Hominy feed, white, 5% fat	10.1	89.9	10.8	5.7	4.7	66.0	2.7	7.7				82.9	363	332
20 Linseed oil meal,33% protein,old process	8.8	91.2	35.0	5.6	8.1	36.9	5.6	30.4	5.1	4.8	30.3	77.1[30]	363	308[31]
21 Molasses, cane	26.0	74.0	2.9	0	0	62.1	9.0	0.1	0	0	55.9	56.0[32]	230	224[33]
22 Oats, excluding Pacific coast	9.8	90.2	12.0	4.6	11.0	58.6	4.0	9.5[34]	3.7[35]	3.1[36]	46.3[37]	67.3[38]	291	269[39]

/1/ Quantity ingested minus quantity in feces, i.e., disappears from alimentary canal. Values are for ruminants and horses except as otherwise specified /2/ Obtained by multiplying total nitrogen by a factor, usually 6.25. /3/Ether extract of finely ground feedstuff material. /4/ Includes fiber (cellulose, lignin) and N-free extract (remainder of carbohydrate, organic acids). /5/ "Total digestible nutrients" (TDN), as commonly calculated, = 1 x col. I + 2.25 x col. J + 1 x col. K + 1 x col. L. /6/Feed calories minus fecal calories, i.e.,virtually absorbed calories before subtraction of urinary loss. Factors used are: protein (col. I) x 5.65; fat (col. J) x 9.3; carbohydrate (col. K, L) x 4.1. Where data on individual digested(-ible) nutrients (col. I-L) are not available, feed calories are calculated as TDN x 4.38 (B. H. Schneider). /7/ Net physiological Calories available for heat, activity and growth. Metabolizable energy = bomb calorimeter energy content of feedstuff minus energy lost in gases produced by fermentation in rumen (chiefly methane),energy lost in feces and energy lost in urine. Factor used is: TDN (col. M) x 4.0. Another factor proposed for use with TDN is 3.6(H. H. Mitchell). /8/ Swine, 33. /9/ Swine, 132. /10/ Chicken, 9.8. /11/ Chicken, 1.5. /12/ Chicken, 0.6. /13/ Chicken, 57.3. /14/ Swine, 72. /15/ Swine, 288. /16/ Chicken, 22.1. /17/ Chicken, 3.9. /18/ Chicken, 31.9. /19/ Chicken, 7.1. /20/ Chicken, 3.4. /21/ Chicken, 0.3. /22/ Chicken, 62. /23/Swine, 78. /24/ Swine, 312. /25/ The physiological effects of some feedstuffs tend to greatly stimulate the excretion of metabolizable products such as nitrogen or fat, and the digestibility of the basal ration is adversely affected. The negative sign, therefore,indicates the net negative contribution to the economy of the animal. /26/ Swine, 69. /27/ Swine, 276. /28/ Swine, 63. /29/ Swine, 252. /30/ Swine, 71. /31/ Swine, 284. /32/ Swine, 58. /33/ Swine, 232. /34/ Chicken, 8.5. /35/ Chicken, 3.7. /36/ Chicken, 2.3. /37/ Chicken, 42.8. /38/ Swine, 63. /39/ Swine, 252.

76. PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF PLANT ORIGIN (Continued)

Values are grams or Calories per 100 grams of feedstuff as fed. For mineral and vitamin composition, see page 138ff.

	Feedstuff / Constituents	Water	Dry Matter	Total Nutrients: Crude Protein[2]	Crude Fat[3]	Total Carbohydrates[4]: Crude Fiber	Total Carbohydrates[4]: N-Free Extract	Ash	Digested(ible) Nutrients[1]: Protein	Fat	Total Carbohydrates[4]: Fiber	Total Carbohydrates[4]: N-Free Extract	"Total Digestible Nutrients"[5]	Digested (-ible) Calories[6]	Metabolizable Calories[7]
		g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	Cal/100g	Cal/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
23	Oats, Pacific coast	8.8	91.2	9.0	5.4	11.0	62.1	3.7	6.6	4.8	3.5	48.4	68.4[38]	295	274[39]
24	Peas, field, seed	9.3	90.7	23.4	1.2	6.1	57.0	3.0	20.1	0.8	3.1	53.0	77.9	351	312
25	Rice bran	9.0	91.0	12.8	13.1	12.7	41.7	10.7	9.2	11.0	4.1	31.7	69.8[30]	301	279[31]
26	Rice grain, brown	12.2	87.8	9.1	2.0	1.1	74.5	1.1	6.1	1.5	0.2	59.6	69.4	294	278
27	Rice polish	9.7	90.3	12.7	11.4	3.5	56.6	6.2	9.7[40]	10.0[41]	1.2[42]	49.7[43]	83.1[44]	357	332[45]
28	Rye, grain	10.5	89.5	12.6	1.7	2.4	70.9	1.9	10.0[46]	0.9[47]	-0.9[25,48]	63.8[49]	75.3[23]	323	301[24]
29	Sorghum, milo	10.6	89.4	11.3	2.9	2.2	71.3	1.7	9.9	2.5	1.1	62.7	79.3[23]	341	317[24]
30	Soybean grain	10.0	90.0	37.9	18.0	5.0	24.5	4.6	34.1[50]	16.2[51]	-0.1[25,52]	15.4[53]	85.8	406	343
31	Soybean oil meal, 41% protein	10.2	89.8	41.1	5.3	5.5	30.4	7.5	34.5				76.4	335	306
32	Soybean oil meal, 44% protein	9.2	90.8	44.2	5.3	5.6	29.9	5.8	37.1				78.6[54]	344	314[55]
33	Soybean oil meal, solvent extract	9.4	90.6	46.1	1.0	5.9	31.8	5.8	42.4	0.5	5.2	29.9	78.7	388	315
34	Wheat, hard red winter	10.4	89.6	15.2	1.8	2.6	68.3	1.7	12.8[56]	1.5[57]	1.8[58]	62.2[59]	80.0[60]	349	320[61]
35	Wheat, soft, Pacific coast	10.8	89.2	9.9	2.0	2.7	72.7	1.9	8.3				80.0	350	320
36	Wheat bran	10.3	89.7	16.4	4.3	9.9	53.0	6.1	12.5[62]	2.8[63]	3.6[64]	39.2[65]	61.3[66]	272	245[67]
37	Wheat flour middlings	10.3	89.7	18.1	4.6	4.9	58.5	3.6	14.7	3.8	1.2	49.7	74.2	327	297
38	Wheat screenings	9.6	90.4	13.9	4.7	9.0	58.2	4.6	10.0	4.1	0.5	48.9	73.5	297	294
39	Wheat standard middlings	9.9	90.1	17.6	5.0	6.7	56.6	4.2	13.7	4.5	2.5	42.5	68.5[68]	299	274[69]
	Dry Roughages														
40	Alfalfa hay	9.5	90.5	14.8	2.0	28.9	36.6	8.2	10.5	0.6	12.7	25.6	50.3	222	201
41	Alfalfa hay, dehydrated	8.0	92.0	16.1	2.4	26.9	39.5	7.1	11.3	1.1	13.2	28.4	55.4	245	222
42	Alfalfa leaf meal, good	7.7	92.3	21.2	2.8	16.6	39.7	12.0	16.1				56.7	248	227

/1/ Quantity ingested minus quantity in feces, i.e., disappears from alimentary canal. Values are for ruminants and horses except as otherwise specified. /2/ Obtained by multiplying total nitrogen by a factor, usually 6.25. /3/ Ether extract of finely ground feedstuff material. /4/ Includes fiber (cellulose, lignin) and N-free extract (remainder of carbohydrate, organic acids). /5/ "Total digestible nutrients" (TDN), as commonly calculated, = 1 x col. I + 2.25 x col. J + 1 x col. K + 1 x col. L. /6/ Feed calories minus fecal calories, i.e., virtually absorbed calories before subtraction of urinary loss. Factors used are: protein (col. I) x 5.65; fat (col. J) x 9.3; carbohydrate (col. K, L) x 4.1. Where data on individual digested(-ible) nutrients (col. I-L) are not available, feed calories are calculated as TDN x 4.38 (B. H. Schneider). /7/ Net physiological Calories available for heat, activity and growth. Metabolizable energy = bomb calorimeter energy content of feedstuff minus energy lost in gases produced by fermentation in rumen (chiefly methane), energy lost in feces and energy lost in urine. Factor used is: TDN (col. M) x 4.0. Another factor proposed for use with TDN is 3.6(H.H. Mitchell). /23/ Swine, 78. /24/ Swine, 312. /25/ The physiological effects of some feedstuffs tend to greatly stimulate the excretion of metabolizable products such as nitrogen or fat, and the digestibility of the basal ration is adversely affected. The negative sign, therefore, indicates the net negative contribution to the economy of the animal. /30/ Swine, 71. /31/ Swine, 284. /38/ Swine, 63. /39/ Swine, 252. /40/ Chicken, 11.1. /41/ Chicken, 5.7. /42/ Chicken, 1.6. /43/ Chicken, 54.9. /44/ Swine, 88. /45/ Swine, 352. /46/ Chicken, 8.8. /47/ Chicken, 1.0. /48/ Chicken, 0.1. /49/ Chicken, 60.3. /50/ Chicken, 34.9. /51/ Chicken, 16.2. /52/ Chicken, 1.9. /53/ Chicken, 10.6. /54/ Swine, 79. /55/ Swine, 316. /56/ Chicken, 13.4. /57/ Chicken, 0.9. /58/ Chicken, 0.3. /59/ Chicken, 60. /60/ Swine, 83. /61/ Swine, 332. /62/ Chicken, 10.2. /63/ Chicken, 2.3. /64/ Chicken, 0.9. /65/ Chicken, 24.4. /66/ Swine, 57. /67/ Swine, 228. /68/ Swine, 65. /69/ Swine, 260.

76. PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF PLANT ORIGIN (Continued)

Values are grams or Calories per 100 grams of feedstuff as fed. For mineral and vitamin composition, see page 138ff.

	Feedstuff	Water	Dry Matter	Total Nutrients: Crude Protein[2]	Crude Fat[3]	Total Carbohydrate[4]: Crude Fiber	Total Carbohydrate[4]: N-Free Extract	Ash	Digested(ible) Nutrients[1]: Protein	Fat	Total Carbohydrate[4]: Fiber	Total Carbohydrate[4]: N-Free Extract	"Total Digestible Nutrients"[5]	Digested (-ible) Calories[6]	Metabolizable Calories[7]
		g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	Cal/100g	Cal/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
43	Bluegrass hay, Kentucky	15.7	84.3	9.5	2.3	25.2	40.1	7.2	5.4	1.2	16.9	25.7	50.3	216	201
44	Brome hay, smooth	13.2	86.8	5.7	4.4	28.5	40.0	8.2	2.6	1.8	15.7	24.8	46.4	197	186
45	Bromegrass hay	11.9	88.1	9.9	2.1	28.4	39.5	8.2	5.0	0.8	16.8	25.3	48.9	208	196
46	Clover hay, alsike	11.1	88.9	12.1	2.1	27.0	39.9	7.8	8.1	1.2	14.6	27.9	53.2	231	213
47	Clover hay, crimson	10.5	89.5	14.2	2.2	27.4	37.0	8.7	9.8	1.0	12.9	24.1	48.9	216	196
48	Clover hay, Ladino	12.0	88.0	19.4	3.2	20.7	34.9	9.8	14.2				54.9	240	220
49	Clover hay, red	11.9	88.1	11.8	2.6	27.2	40.1	6.4	7.1	1.5	14.4	27.3	52.2	225	209
50	Clover and mixed grass hay, high in clover	10.3	89.7	9.6	2.7	28.8	42.4	6.2	5.5	1.3	17.6	26.3	52.2	223	209
51	Clover and timothy hay, 30-50% clover	11.9	88.1	8.6	2.2	30.3	41.2	5.8	4.8	1.2	17.3	26.4	51.2	217	205
52	Corn cobs, ground	9.6	90.4	2.3	0.4	32.1	54.0	1.6	0	0.1	18.0	27.5	45.7	187	183
53	Corn fodder, medium in water	17.4	82.6	6.8	2.1	21.8	46.7	5.2	3.3				53.9	236	216
54	Cowpea hay	9.6	90.4	18.6	2.6	23.3	34.6	11.3	12.3	1.2	11.9	24.6	51.4	230	206
55	Grass hay, mixed	10.1	89.9	6.7	1.8	28.9	44.9	7.6	2.7	0.7	18.5	26.9	51.2	208	205
56	Lespedeza hay, annual, in bloom	10.9	89.1	13.0	1.8	26.5	42.7	5.1	6.5	0.6	12.7	26.9	47.5	215	190
57	Oat hay	11.9	88.1	8.2	2.7	28.1	42.2	6.9	4.9	1.8	14.3	24.1	47.3	202	189
58	Oat straw	10.3	89.7	4.1	2.2	36.1	41.0	6.3	0.7	0.8	21.3	20.9	44.7	184	179
59	Orchardgrass hay	14.2	85.2	6.9	2.6	30.9	38.6	6.8	3.5	1.2	18.2	20.5	45.2	190	181
60	Prairie hay, western, good quality	9.3	90.7	5.7	2.3	30.4	44.9	7.4	2.1	0.9	19.5	26.0	49.6	207	198
61	Red top hay	9.3	90.7	8.5	3.4	26.8	47.7	4.3	5.3	1.8	16.3	30.1	55.7	237	223
62	Sorghum fodder, sweet, dry	11.2	88.8	6.2	2.4	25.0	48.1	7.1	3.3	1.5	15.3	30.3	52.4	220	210
63	Soybean hay, good	12.0	88.0	14.4	3.3	27.5	35.8	7.0	9.6	1.5	12.7	23.3	49.0	216	196
64	Sudan grass hay	10.7	89.3	8.8	1.6	27.9	42.9	8.1	4.3	0.8	17.9	24.5	48.5	206	194

/1/ Quantity ingested minus quantity in feces, i.e., disappears from alimentary canal. Values are for ruminants and horses except as otherwise specified. /2/ Obtained by multiplying total nitrogen by a factor, usually 6.25. /3/ Ether extract of finely ground feedstuff material. /4/ Includes fiber (cellulose, lignin) and N-free extract (remainder of carbohydrate, organic acids). /5/ "Total digestible nutrients" (TDN), as commonly calculated, = 1 x col. I + 2.25 x col. J + 1 x col. K + 1 x col. L. /6/ Feed calories minus fecal calories, i.e., virtually absorbed calories before subtraction of urinary loss. Factors used are: protein (col. I) x 5.65; fat (col. J) x 9.3; carbohydrate (col. K, L) x 4.1. Where data on individual digested(-ible) nutrients (col. I-L) are not available, feed calories are calculated as TDN x 4.38 (B. H. Schneider). /7/ Net physiological Calories available for heat, activity and growth. Metabolizable energy = bomb calorimeter energy content of feedstuff minus energy lost in gases produced by fermentation in rumen (chiefly methane), energy lost in feces and energy lost in urine. Factor used is: TDN (col. M) x 4.0. Another factor proposed for use with TDN is 3.6 (H. H. Mitchell).

76. PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF PLANT ORIGIN (Concluded)

Values are grams or Calories per 100 grams of feedstuff as fed. For mineral and vitamin composition, see page 138ff.

	Feedstuff	Water	Dry Matter	Total Nutrients					Digested(ible) Nutrients[1]					Digested (-ible) Calories[6]	Metabolizable Calories[7]
				Crude Protein[2]	Crude Fat[3]	Total Carbohydrate[4]		Ash	Protein	Fat	Total Carbohydrate[4]		"Total Digestible Nutrients"[5]		
						Crude Fiber	N-Free Extract				Fiber	N-Free Extract			
		g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	g/100g	Cal/100g	Cal/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
65	Sweetclover hay	7.8	92.2	15.8	1.6	24.7	39.3	10.8	11.9	0.5	8.4	28.3	49.7	222	199
66	Timothy hay	11.0	89.0	6.5	2.4	30.2	45.0	4.9	2.9	1.1	16.9	26.6	48.9	205	196
67	Vetch hay, common	14.8	85.2	18.7	1.8	22.2	34.7	7.8	14.4	0.9	10.4	25.3	53.8	236	215
68	Wheat hay	9.6	90.4	6.1	1.8	26.1	50.0	6.4	3.3	0.7	10.7	31.0	46.7	196	187
69	Wheat straw	7.5	92.5	3.9	1.5	36.9	41.9	8.3	0.3	0.6	19.2	19.7	40.6	167	162
	Silages														
70	Alfalfa, prebloom	66.5	33.5	6.6	1.3	10.1	12.4	3.1	4.7	0.8	5.4	8.3	20.1	90	80
71	Alfalfa, in bloom	65.7	34.3	5.7	1.1	11.0	13.8	2.8	3.9	0.7	5.8	8.8	20.0	88	80
72	Alfalfa, slightly wilted	64.0	36.0	6.0	1.4	11.7	13.7	3.2	4.1	0.9	6.4	8.8	21.3	94	85
73	Alfalfa-molasses, not wilted	73.2	26.8	4.1	0.9	8.2	11.2	2.4	2.7	0.5	3.9	7.6	15.4	67	62
74	Beet top, sugar	68.4	31.6	3.8	0.6	3.9	10.8	12.5	2.6	0.2	3.2	8.6	14.9	65	60
75	Corn, dent, well matured	72.6	27.4	2.2	0.8	6.7	16.1	1.6	1.2	0.5	4.4	11.1	18.1	75	72
76	Corn and soybeans, well matured, 30% soybeans	71.7	28.3	3.2	1.2	7.3	14.2	2.4	2.0	1.0	4.5	10.9	19.7	84	79
77	Cowpea	78.6	21.4	3.3	0.7	5.6	9.3	2.5	1.9	0.4	2.9	6.8	12.5	54	50
78	Grass silage, large proportion legumes, wilted	66.7	33.3	5.2	1.3	8.8	14.2	3.8	2.9	0.7	6.0	8.7	19.1	83	76
79	Grass silage, small proportion legumes, wilted slightly, molasses added	71.0	29.0	3.0	0.9	8.9	14.2	2.0	1.6	0.6	5.9	9.2	18.0	77	72
80	Sorghum, sweet	74.7	25.3	1.6	0.8	6.9	14.4	1.6	0.8	0.5	3.9	9.4	15.2	64	61
81	Sweetclover	71.0	29.0	6.3	1.0	9.1	9.7	2.9	4.9	0.6	3.7	6.7	17.1	76	68

/1/ Quantity ingested minus quantity in feces, i.e., disappears from alimentary canal. Values are for ruminants and horses except as otherwise specified. /2/ Obtained by multiplying total nitrogen by a factor, usually 6.25. /3/ Ether extract of finely ground feedstuff material. /4/ Includes fiber (cellulose, lignin) and N-free extract (remainder of carbohydrate, organic acids). /5/ "Total digestible nutrients" (TDN), as commonly calculated, = 1 x col. I + 2.25 x col. J + 1 x col. K + 1 x col. L. /6/ Feed calories minus fecal calories, i.e., virtually absorbed calories before subtraction of urinary loss. Factors used are: protein (col. I) x 5.65; fat (col. J) x 9.3; carbohydrate (col. K, L) x 4.1. Where data on individual digested(-ible) nutrients (col. I-L) are not available, feed calories are calculated as TDN x 4.38 (H. H. Schneider). /7/ Net physiological Calories available for heat, activity and growth. Metabolizable energy = bomb calorimeter energy content of feedstuff minus energy lost in gases produced by fermentation in rumen (chiefly methane), energy lost in feces and energy lost in urine. Factor used is: TDN (col. M) x 4.0. Another factor proposed for use with TDN is 3.6 (H. H. Mitchell).

77. MINERAL AND VITAMIN COMPOSITION: FEEDSTUFFS OF PLANT ORIGIN

Values are milligrams or grams per 100 grams of feedstuff as fed.

	Feedstuff \ Constituents	Minerals					Vitamins				
		Calcium	Copper	Iron	Manganese	Phosphorus	Vitamin A as β-carotene[1]	Niacin	Pantothenic Acid	Riboflavine	Thiamine
		g/100g	mg/100g	mg/100g[2]	mg/100g	g/100g	mg/100g	mg/100g[2]	mg/100g	mg/100g	mg/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Concentrates										
1	Alfalfa meal,dehydrated,17% protein	1.70	0.68	33	3.30	0.22	7.92	1.91	2.71	1.61	0.33
2	Alfalfa meal,dehydrated,20% protein	1.66	1.56	39	6.29	0.31	13.2	3.81	4.07	1.63	0.68
3	Alfalfa meal,sun-cured,17% protein						5.28			1.94	
4	Barley,excluding Pacific coast	0.09	1.12	4.9	1.83	0.47		5.31	0.81	0.18	0.37
5	Barley,Pacific coast	0.06	1.12	6.8	1.72	0.41		4.41	0.73	0.13	0.40
6	Beet pulp,molasses,dried	0.62	1.3	28	3.9	0.09		1.9	1.2	0.1	0.02
7	Brewers' dried yeast	0.11	3.32	13.8	0.53	1.52		47	10.81	3.08	9.47
8	Brewers' grains,dried,25% protein	0.25	2.4	2.8	4.3	0.49		4.1	1.2	0.1	0.04
9	Citrus pulp,dried	2.06	0.86	15.0	0.44	0.15	0.02	2.11	1.32	0.22	0.13
10	Corn & cob meal (corn ears ground)					0.22					
11	Corn,dent,yellow	0.02	0.20	2.0	0.51	0.27	0.29	2.16	0.57	0.11	0.37
12	Corn gluten feed,25% protein	0.41	4.58	42	2.25	0.82	1.3	6.65	1.72	0.18	0.007
13	Corn gluten meal,41% protein	0.20	2.88	47	0.97	0.41	2.2	5.46	0.84	0.15	0.02
14	Cottonseed hulls	0.14				0.07				0.37	
15	Cottonseed meal,41% protein	0.18	1.69	7.6	2.84	1.14		2.86	0.97	0.55	0.39
16	Distillers' dried corn grains	0.11	4.49	24.0	3.28	0.52		4.65	1.17	0.35	0.24
17	Distillers' dried corn grains, with solubles	0.16			4.01	0.74		7.99	1.14	0.75	0.46
18	Distillers' dried solubles	0.35	7.99	50	10.00	1.40	0.2	11.96	1.96	1.15	0.59
19	Hominy feed,white,5% fat	0.05	2.18	3.9	1.81	1.03		5.52	0.68	0.22	1.30
20	Linseed oil meal,33% protein old process	0.44	2.59	24.0	4.21	0.94		4.16	1.65	0.42	0.86
21	Molasses,cane	0.74				0.08		4.60	3.94	0.24	0.09
22	Oats,excluding Pacific coast	0.09	0.53	8.0	4.23	0.43		1.81	1.50	0.09	0.64
23	Oats,Pacific coast										
24	Peas,field,seed	0.17				0.51		3.79	1.01	0.18	3.97
25	Rice bran	0.08			15.61	1.36		28	2.27	0.31	2.27
26	Rice grain,brown		0.26	1.0	2.03	0.25		3.77		0.07	0.24
27	Rice polish	0.04				1.10		73	1.21	0.20	1.94
28	Rye grain	0.01	0.75	8.0	8.14	0.33		1.56	0.93	0.15	0.44
29	Sorghum,milo	0.04	1.72	5.3	1.30	0.27		2.88	1.10	0.09	0.40
30	Soybean grain	0.27	1.69	10.0	2.62	0.62		2.20	1.56	0.26	1.10
31	Soybean oil meal,41% protein	0.26	2.44	17.0	2.71	0.59				0.55	
32	Soybean oil meal,44% protein	0.30	1.70	15.0	3.08	0.66		3.67	1.34	0.44	0.18
33	Soybean oil meal,solvent extract	0.29	1.50	10.0	3.04	0.63		3.77	1.37	0.31	0.31
34	Wheat,hard,red winter	0.05	0.44	5.3	3.96	0.41		5.31	1.39	0.11	0.51
35	Wheat,soft,Pacific coast		0.97	6.9	6.10	0.29		5.90	1.15	0.11	0.48
36	Wheat bran	0.14	1.08	16.2	12.33	1.30		13.99	2.99	0.31	0.86
37	Wheat flour middlings	0.07	0.46	2.2	8.59	0.65		9.74	0.99	0.18	1.32
38	Wheat screenings										
39	Wheat standard middlings	0.14	2.16	9.0	11.80	0.78		9.75	2.05	0.18	1.28
	Dry Roughages										
40	Alfalfa hay	1.47	0.81	25	4.51	0.24	2.51	3.83	1.78	1.36	0.29
41	Alfalfa hay,dehydrated	1.38				0.25	9.55	1.47	3.83	1.47	0.44
42	Alfalfa leaf meal,good	1.69			6.07	0.25	6.60	1.58	2.77	1.58	0.44
43	Bluegrass hay,Kentucky	0.46	0.90	25	7.65	0.32			0.99		
44	Brome hay,smooth										
45	Bromegrass hay	0.20			3.30	0.28		3.74			

/1/ 0.0006 mg β-carotene = 1 I.U. vitamin A. /2/ Values of 25 and above are rounded to the nearest whole number.

77. MINERAL AND VITAMIN COMPOSITION: FEEDSTUFFS OF PLANT ORIGIN (Concluded)

Values are milligrams or grams per 100 grams of feedstuff as fed.

	Feedstuff / Constituents	Minerals					Vitamins				
		Calcium	Copper	Iron	Manganese	Phosphorus	Vitamin A as β-carotene[1]	Niacin	Pantothenic Acid	Riboflavine	Thiamine
		g/100g	mg/100g	mg/100g[2]	mg/100g	g/100g	mg/100g	mg/100g[2]	mg/100g	mg/100g	mg/100g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Dry Roughages (Concluded)										
46	Clover hay, alsike	1.15	0.53	40	10.38	0.23	10.4				
47	Clover hay, crimson	1.23			21.98	0.24					
48	Clover hay, Ladino	1.32		99	15.97	0.29					
49	Clover hay, red	1.35	0.88	27	10.65	0.19	1.89	3.72	0.99	1.56	0.19
50	Clover & mixed grass hay, high in clover	0.90	0.70	22.0	9.26	0.19	0.70				
51	Clover & Timothy hay, 30-50% clover	0.68	0.62	19.0	8.58	0.20					
52	Corn cobs, ground					0.02					
53	Corn fodder, medium in water	0.21				0.14	0.39				
54	Cowpea hay	1.37		82		0.29					
55	Grass hay, mixed	0.48		56		0.21					
56	Lespedeza hay, annual, in bloom	1.02		25	13.47	0.18					
57	Oat hay	0.21		49	8.05	0.19					
58	Oat straw	0.19	0.99	18.0	2.97	0.10					
59	Orchardgrass hay	0.19				0.17					
60	Prairie hay, western, good quality	0.36				0.18	2.05				
61	Red top, hay	0.38	0.35	11.0	2.06	0.23					
62	Sorghum fodder, sweet, dry	0.34			11.59	0.12	0.24				
63	Soybean hay, good	1.35				0.25	2.99				
64	Sudan grass hay	0.36		13.0	8.16	0.26	8.2				
65	Sweetclover hay	1.25	0.90	12.0	10.69	0.23					
66	Timothy hay	0.23				0.20	1.17	3.41		0.90	0.13
67	Vetch hay, common	1.13	0.88	28	4.7	0.32					
68	Wheat hay	0.14				0.18					
69	Wheat straw	0.21	0.29	16.0	5.08	0.07					
	Silages										
70	Alfalfa, prebloom										
71	Alfalfa, in bloom										
72	Alfalfa, slightly wilted	0.51	0.33	11.0	1.87	0.12	3.28				
73	Alfalfa-molasses, not wilted	0.41				0.08	3.19				
74	Beet top, sugar	0.31				0.07	1.12				
75	Corn, dent, well matured	0.10	0.13	3.0	1.94	0.06	1.41	1.25			
76	Corn & soybeans, well matured, 30% soybeans	0.20				0.08					
77	Cowpea	0.48		29		0.10					
78	Grass silage, large proportion legumes, wilted						5.35				
79	Grass silage, small proportion legumes, wilted slightly, molasses added					0.07					
80	Sorghum, sweet	0.08			3.3	0.04	0.59				
81	Sweetclover										

/1/ 0.0006 mg β-carotene=1 I.U. vitamin A. /2/ Values of 25 and above are rounded to the nearest whole number.

78. STABILITY AND LABILITY OF NUTRIENTS

Nutrients are especially sensitive to the reaction (pH) of the solvent, and to exposure to air, light and heat. Unless otherwise stated, reference is made to the properties of the nutrient in aqueous solution. Where no footnote is given, the stability of the nutrient is estimated on the basis of its chemical composition, or other well known properties.

S = Stable, i.e., nutrient exhibits no appreciable breakdown under conditions specified in footnote. L = Labile, i.e., nutrient exhibits appreciable decomposition under conditions specified in footnote.

	Nutrient	Hydrogen Ion Concentration			Oxygen, Atmospheric	Light	Heat	Loss in Ordinary Cooking[1]
		Neutral	Acid	Alkaline				
		pH 7	< pH 7	> pH 7				%
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Vitamins							
1	A	S[2]			L[2]	L[3]	S[2]	10-30
2	Ascorbic acid	L[4]	S[4]	L[4]	L[4]	L[4]	L[4]	20-80
3	Biotin	S	S[5]	S[5]	S[6]	S[6]	S[5]	0-72
4	Choline	S	S[7]	S	L	S	S	
5	Cobalamin[8]	S[9]	S[9]	S[9]	L	L	S[9]	
6	D_2[10]	S[11]		L[12]	L[12,13]	L[13]	L	Appreciable
7	E	S	S[14]	S	L[14]	L[15]	S[14]	50[16]
8	Folic acid group[17]	L	L[18]	S[18,19]	L[19]	L[20]	S[18]	0-97
9	Inositol	S	S[21]	S	S	S	S[21]	0-95
10	K	S	S	L[22]	S	L	S	
11	Niacin[23]	S[24]	S[24]	S[24]	S	S	S[24]	0-72
12	Pantothenic acid	S[25]	L[25]	L[25]	S	S	L	0-44
13	Para-aminobenzoic acid	S[26]	S[27]	S[28]	L	S	S	
14	Pyridoxine group[29]	S[30]	S[30]	S[30]	S[31]	L[32]	S[30]	
15	Riboflavine	S[33]	S[34]	L[35]	S[34]	L[35,36]	S[33,35]	0-48

/1/ Nutrient lost expressed as percentage of quantity of nutrient present before cooking. /2/ Stable in an inert atmosphere; loses biological activity if heated in presence of oxygen for 5.5 hours. /3/ Destroyed by ultraviolet light (UV). /4/ Decomposes in light; decomposition accelerated by oxygen, metal ions. /5/ 50% loss if heated in 20% HCl to 120° C for 6 hours; 40-60% loss if heated in 1 N KOH to 120° C for 17 hours. /6/ Stable to air, O_2, and UV. /7/ Stable when autoclaved in 3 N HCl for 2 hours. /8/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product. (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /9/ Stable for 2 hours at room temperature in 0.1 N acid or alkali and in boiling water at pH 7 for 2 hours. /10/ Calciferol. /11/ Stable in dry propylene glycol more than three years when stored in amber bottles. /12/ Some loss in alkaline feeds, e.g., lime. /13/ Activity lost in mixed feeds, also under prolonged irradiation in presence of oxygen. /14/ In absence of oxygen, stable to heat up to 200° C, and not affected by H_2SO_4 and HCl at 100° C. /15/ Tocopherols stable to visible light but readily destroyed by UV. /16/ Deep fat frying and baking result in appreciable destruction. /17/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U,L. casei factor, Norite elute factor. /18/ No destruction at pH 6.8 and 100°C for 30 minutes; 70-100% loss on autoclaving in pH range 4-12. /19/ Aeration at pH 10 causes partial inactivation. /20/ Rapidly inactivated by light. /21/ Stable to refluxing with 10% HCl for 6 hours, to alkali and to a variety of chemical agents. /22/ Sensitive to alkali. /23/ Nicotinamide; nicotinic acid. The nicotinamide is partially hydrolyzed by alkali and acid, but the product, nicotinic acid, having the same vitamin activity as nicotinamide retains its biological activity. /24/ Autoclaving with water, acid, or alkali used in extracting nicotinamide from mixture with other food substances. /25/ Maximum stability over pH range 5.5-7.0; rapidly hydrolyzed under more acidic or alkaline conditions. /26/ Maximum yields obtained by autoclaving aqueous solutions. /27/ Only 15% destruction on autoclaving solutions in 6 N H_2SO_4 for 60 minutes. /28/ Probably stable to autoclaving with 1 N NaOH, but long treatment with alkali results in destruction. /29/ Includes pyridoxine, pyridoxal, pyridoxamine. /30/ Pyridoxine not destroyed by heating with 5 N acid or alkali at 100° C, or autoclaving in acid or alkali; pyridoxal and pyridoxamine stable in hot acid, but pyridoxal partially decomposed by hot alkali. /31/ Oxidized only by such strong agents as hot HNO_3, H_2O_2. /32/ Rapidly destroyed by UV in neutral or alkaline solution. /33/ Stable in neutral or acid solutions. /34/ 1.2% decomposed per month at pH 5.0 at 27° C. /35/ Destruction rate in presence of light increases as pH and temperature increase. /36/ 50% of the riboflavine of milk destroyed when exposed to sunlight for 2 hours.

78. STABILITY AND LABILITY OF NUTRIENTS (Concluded)

Nutrients are especially sensitive to the reaction (pH) of the solvent, and to exposure to air, light and heat. Unless otherwise stated, reference is made to the properties of the nutrient in aqueous solution. Where no footnote is given, the stability of the nutrient is estimated on the basis of its chemical composition, or other well known properties.

S = Stable, i.e., nutrient exhibits no appreciable breakdown under conditions specified in footnote. L = Labile, i.e., nutrient exhibits appreciable decomposition under conditions specified in footnote.

	Nutrient	Hydrogen Ion Concentration			Oxygen, Atmospheric	Light	Heat	Loss in Ordinary Cooking[1]
		Neutral	Acid	Alkaline				
		pH 7	< pH 7	> pH 7				%
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Vitamins (concluded)							
16	Thiamine	L[37]	S[38]	L[39]	L[40]	S	S[38,41]; L[37,39]	25-45
	Unsaturated fatty acids							
17	Linoleic, linolenic, Arachidonic	S	S	L[42]	L[43]	L[43]	S[42,44]	< 10[44]
	Amino acids							
18	Isoleucine	S	S	S[45]	S	S	S	Very small
19	Leucine	S	S	S[45]	S	S	S	Very small
20	Lysine	S	S	S[45]	S	S	S	Very small
21	Methionine	S	S	S[45]	S	S	S	Very small
22	Phenylalanine	S	S	S[45]	S	L[46]	S	Very small
23	Threonine	S	S[47]	L[45]	S	S	S	Very small
24	Tryptophan	S	L[47]	S[45]	S	L[46]	S	Very small
25	Valine	S	S	S[45]	S	S	S	Very small
26	Inorganic salts	S	S	S	L[48]	S	S	Very small

/37/ 96.4% destroyed at 100°C at pH 7 in 3 hours. /38/ No destruction in 1% HCl in 7 hours at 100° C. /39/ 100% destroyed in 15 minutes at pH 9 at 100°C. /40/ Unstable in presence of air. /41/ Heat stability a function of pH and nature of buffer. /42/ Isomerization of double bonds occurs in 7 minutes in 20% KOH at 178°C, although these vitagens appear to be less labile at lower temperatures. /43/ Sensitive to light and air oxidation. /44/ Almost no destruction of multiple unsaturated fatty acids by heat, unless in strongly alkaline solution (cf. Fn 42). /45/ Most amino acids undergo racemization in alkaline solutions, but they are otherwise stable. /46/ Modified by UV. /47/ Tryptophan completely destroyed by hot 20% HCl in 12 hours; threonine undergoes slight destruction. Only partial destruction on refluxing with 2.5 N H_2SO_4 for 6 hours. /48/ Oxidation of some inorganic salts of lower valence states to higher valence states when exposed to atmospheric oxygen, i.e., ferrous to ferric iron.

79. FOOD NUTRIENT LOSSES IN COOKING

Each value is the nutrient lost in cooking expressed as a percentage of the quantity of the same nutrient present in the uncooked edible portion of the food material. Values are roughly approximate only.

	Food Type	Species	Method of Cooking	Minerals			Vitamins[1]				
				Calcium	Iron	Phosphorus	Vitamin A	Ascorbic Acid	Niacin	Riboflavine	Thiamine
				%	%	%	%	%	%	%	%
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	Plant Food										
1	Cabbage[2]	Brussels sprouts	Boiling: retaining water					10	25	1	
2			discarding water					40	25	15	
3		Cabbage	Pressure saucepan					30			
4			Steaming					50	20	15	
5	Cereals	Rolled oats	Double boiler: 15 min.						0[3]	0[3]	0
6			30 min.						0	0[3]	2
7			120 min.						0[3]	0[3]	8
8	Corn[2]	Corn	Boiling					35	15	10	20
9	Flowers and shoots[2]	Asparagus	Boiling: retaining water				0	10	15		1
10		Broccoli	discarding water	20	5	15	0	30	25	35	40
11		Cauliflower	Pressure saucepan					30			
12			Steaming				0	25	15	15	15
13	Leafy[2]	Kale	Boiling: retaining water					25	20	10	5
14		Spinach	discarding water	20	5	15		50	25	30	30
15		Swiss chard	Pressure saucepan					50			
16		and others	Steaming					60	10	15	15
17	Legumes, fresh[2]	Beans	Boiling: retaining water					5	5	0	10
18		Peas	discarding water	0	1	5	15	40	20	20	20
19			Steaming				10	15	0	5	5
20	Potatoes[2]	Potato	Baking					25			
21			Boiled in jackets					0			
22			Boiling: retaining water						15		
23			discarding water	15	10	0		20	20	25	20
24			Mashed					50			
25			Pressure saucepan					30	0	5	5
26			Steaming					15			
27	Roots and bulbs[2]	Beet	Boiling: retaining water				5	10	15	15	
28		Carrot	discarding water	1	5	0		65	35		
29		Onion	Pressure saucepan	25	5	15					
30		Parsnip Turnip	Steaming				5	50	40	0	25
31	Squash[2]	Squash	Steaming					55			50
	Animal Food										
32	Meats	Unspecified	Braising: retaining drippings						10	5	40
33			discarding drippings						35	25	55
34			Broiling: retaining drippings						5	10	25
35			discarding drippings						20	20	30
36			Roasting: retaining drippings						5	10	30
37			discarding drippings						20	15	40
38			Stewing: retaining water						0	0	50
39			discarding water						50	30	75
40	Fish	Unspecified	Frying						5	10	
41			Steaming						5	0	

/1/ Loss of water soluble vitamins increases in proportion to amount of cooking water used. /2/ Cooked immediately, without standing, after preparation.

80. APPARENT DIGESTIBILITY AND ABSORBABILITY OF NUTRIENTS: VERTEBRATES

Values are grams of protein, fat or carbohydrate digested and virtually absorbed per 100 g of the nutrient ingested as part of the foodstuff or feedstuff listed. The quantity apparently digested and virtually absorbed is taken as the quantity of the nutrient ingested minus the quantity of the same nutrient subsequently found in the feces. Fecal "protein" (= 6.25 x fecal N) includes amino acids, other N compounds. Fecal fat (= ether extract) includes bacterial lipids, also lipids excreted through intestinal wall. Values for man are for the food as commonly prepared for ingestion. Values are subject to marked change with variation in the diet. High dietary cellulose content increases fecal losses of other nutrients.

	Food- or Feedstuff	Apparent Quantity of Nutrient Digested and Absorbed													
		Man			Cattle				Horse				Chicken		
		Protein	Carbohydrate	Fat	Protein	Carbohydrate		Fat	Protein	Carbohydrate		Fat	Protein	Carbohydrate[1]	Fat
						Fiber	NFE[1]			Fiber	NFE[1]				
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
1	Animal products[2]	97	98	95											
2	Bone meal												87	34	93
3	Buttermilk, dried												69	71	95
4	Eggs	97	98	95											
5	Fats			95[3]											
6	Fish meal				76			97					75	35	83
7	Liver meal												65	45	91
8	Meat and fish	97		95											
9	Meat scrap												61	60	90
10	Milk, milk products	97	98	95	96[4]		99[4]	100[4]	91[4]		90[4]	90[4]			
11	Milk, skim, dried				96[4]		100[4]	38[4]					75	66	57
12	Plant products[2]	85	97	90	70?	40?	76?	77?					76?	69?	80?
13	Concentrates														
14	Cereal, grains, seeds														
15	Barley				70	6	88	63	88	39	87	25	73	80	75
16	Corn, gluten meal				86[5]	70[5]	88[5]	74[5]					81	57	55
17	Corn, meal, degermed	76	99	90											
18	Corn meal, whole, ground	60	96	90	63[6]	13[6]	88[6]	83[6]	69[6]	31[6,7]	89[6]	59[6]	86	94	90
19	Cottonseed meal				81	57[8]	80	92					70	36	97
20	Linseed oil meal, old process				85	11[8]	78	93	84		53	35			
21	Macaroni, spaghetti	86	98	90											
22	Oat meal, rolled oats	76	98	90											
23	Oats, whole grain				74	13	76	84	77	10	74	66	56	66	92

/1/ Nitrogen-free extract. /2/ Variety not specified. /3/ Digestibility varies inversely with saturation and length of carbon chain, and is less in infants than adults. /4/ Refers to milk and animal of particular species. /5/ Corn gluten feed. /6/ Corn grain. /7/ For explanation of the minus value see Fn 8. /8/ Some feedstuffs, when ingested either (a) stimulate intestinal excretion of nutrients, specifically nitrogen ("protein") or lipids, or (b) decrease the digestibility of nutrients, e.g., fiber. The negative percentage digestibility refers to this action. Ingestion of linseed oil meal causes more fiber to be lost in the feces than was originally contained in the quantity of oil meal ingested. The additional fiber thus lost, comes from other roughages (whose digestibility is known) fed along with the oil meal.

80. APPARENT DIGESTIBILITY AND ABSORBABILITY OF NUTRIENTS: VERTEBRATES (Concluded)

Values are grams of protein, fat or carbohydrate digested and virtually absorbed per 100 g of the nutrient ingested as part of the foodstuff or feedstuff listed. The quantity apparently digested and virtually absorbed is taken as the quantity of the nutrient ingested minus the quantity of the same nutrient subsequently found in the feces. Fecal "protein" (= 6.25 x fecal N) includes amino acids, other N compounds. Fecal fat (= ether extract) includes bacterial lipids, also lipids excreted through intestinal wall. Values for man are for the food as commonly prepared for ingestion. Values are subject to marked change with variation in the diet. High dietary cellulose content increases fecal losses of other nutrients.

Apparent Quantity of Nutrient Digested and Absorbed

	Food- or Feedstuff	Man			Cattle				Horse				Chicken		
		Protein	Carbohydrate	Fat	Protein	Carbohydrate		Fat	Protein	Carbohydrate		Fat	Protein	Carbohydrate[1]	Fat
						Fiber	NFE[1]			Fiber	NFE[1]				
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)
	Cereal, grains, seeds (concluded)														
24	Peanut meal												74	51	91
25	Rice, brown	75	98	90											
26	Rice, white or polished	84	99	90											
27	Soybean oil meal				86	85	72	88					74	34	79
28	Wheat, 97-100% extraction	79	90	90											
29	Wheat, 85-93% extraction	83	94	90											
30	Wheat, 70-74% extraction	89	98	90											
31	Wheat, whole grain												93	95	96
32	Wheat bran				76	30	76	74	73	22	53	27	59	37	86
33	Wheat middlings												68	63	86
34	Fat			95				77							88
35	Fruit	85	90	90											
36	Potatoes	74	96	90					63	75	101	42			
37	Sugar		98						70	32	83	50			
38	Yeast								91		103		69	54	48
39	Roughages														
40	Green roughages														
41	Kentucky bluegrass				68	70	65	51							
42	Pasture grass, mixed				75	74	77	42							
43	Silage, corn				45	64	69	70							
44	Timothy				59	68	72	57							
45	Dried roughages														
46	Alfalfa hay				71	55	70	58	69	36	61	0			
47	Alfalfa meal												56	34	55
48	Clover hay				49	46	62	47	56	38	64	29			
49	Timothy hay				36	51	62	63	43	43	53	13			

/1/ Nitrogen-free extract.

81. CALORIE VALUES OF NUTRIENTS

Each Calorie value applies to 1 gram of the ingested nutrient -- protein, carbohydrate, fat -- of origin specified at head of its column. The quantities and percentages, except for the values in line 1, are subject to marked change with variation in the diet. High dietary cellulose content increases fecal losses of other nutrients.

One Gram of Ingested Nutrient	Man						Monkey				Cattle				Chicken		
	Caloric Value for						Caloric Value for				Caloric Value for				Caloric Value for		
	Protein		Carbohydrate[1]		Fat		Protein		Carbohydrate[1]	Fat	Protein	Carbohydrate		Fat	Protein	Carbohydrate[1]	Fat
	From Plant	From Animal	From Plant	From Animal	From Plant	From Animal	From Plant	From Animal	Mostly Plant	Mostly Plant	From Plant	Plant Fiber[1]	Plant NFE[2]	From Plant			
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)
1 Total energy content by bomb calorimeter[3]	5.65	5.65	4.15	3.90	9.30	9.40	5.65	5.65	4.1	9.3	5.65	4.25	4.23	8.72[4]	5.70	4.20	9.47[5]
2 Lost in rumen gases[6]												0.33	0.47				
3 Lost in feces[7]	0.85[8]	0.15[8]	0.15[9]	0.10[9]	0.95[10]	0.45[10]	0.56[11]	0.56[11]	0	0	1.64[12]	1.89	0.95	2.90[13]	1.37[14]	0.84[14]	1.89[14]
4 Virtually absorbed[15]	4.80	5.50	4.00	3.80	8.35	8.95	5.09	5.09	?	?	4.01	2.03	2.81	5.82	4.33	3.36	7.58
5 Virtually absorbed as % of 1A	85	97+	97-	98-	90-	95+	90	90			71	48	66	67	76	80	80
6 Virtually absorbed as % of 1A on average diet	92[16]		97[17]		95[18]		90				71	62[19,20]		67	76	80	80
7 Lost in urine[21]	1.06[22]	1.21[22]	0	0	0	0	1.68[23]	2.04[23]	0	0	1.30[24]	0	0	0	0.87?	0	0
8 Lost in urine as % of 4A	22	22					33	40			32				20?		
9 Lost in urine as % of 4A on average diet	22[16]						39.3[25]				32				20?		
10 Metabolized for heat, activity, growth[26]	3.74	4.29	4.00	3.80	8.35	8.95	3.41	3.05	?	?	2.71	2.03	2.81	5.82	3.46	3.36	7.58
11 Metabolized for heat, activity, growth[26] on average diet	4.08[16]		3.99[17]		8.90[18]		3.09[25]				2.71[20]	2.6[19,20]		5.82[20]	3.46	3.36	7.58
12 Metabolized (line 11) rounded off to:	4.0		4.0		9.0						2.7	2.6		5.8			

/1/ Carbohydrate of plant origin (except from potatoes, white flour, starch, etc.) is likely to include more or less of "fiber", chiefly cellulose. This carbohydrate has the same bomb calorimeter value as has starch, but is poorly digested, except by ruminants. In these, fermentation in the rumen breaks down complex carbohydrates to simpler forms (including organic acids) that are digestible or directly absorbable (see also Fn 6). /2/ NFE = nitrogen free extract = hemicellulose, starch, sugar, organic acids, etc. /3/ 1 gram of (chemically pure) nutrient specified at top of column, burned, yields Calories as given. /4/ Mean of 7.96 for fat from roughage and 9.47 for fat from grain. /5/ Fat from grain. /6/ From fermentation of fiber and NFE (Fn 2) in rumen of cattle. A 550 kg cow may lose 4,000 Calories/day (= 400 liters of methane). /7/ Fecal nitrogen x 6.25 = "protein". Fecal fat (= ether extract) contains excreted lipids and fecal bacterial lipids. /8/ Fecal protein = 15% of ingested protein if of plant origin; 3% if of animal origin; 8% on average diet. /9/ Fecal carbohydrate = 3% of ingested carbohydrate if of plant origin; 2% if of animal origin; 3% on average diet. The fecal loss is larger if plant carbohydrate includes much cellulose. /10/ Fecal fat = 10% of ingested fat if of plant origin; 5% of ingested animal fat; 5% on average diet. /11/ Fecal protein = 10% of ingested protein. /12/ Lost in feces: 30% of protein from roughage and 25% of protein from concentrates. Approximately 44% of dietary protein is from roughage, 56% from concentrates. /13/ Lost in feces: 49% of fat from roughage and 18% of fat from concentrates. Approximately 50% of dietary fat is from roughages, 50% from concentrates. /14/ Consistent with digestibility coefficients of Fraps (ref. 11), applied to a growing ration. /15/ Line 1 minus lines 2 and 3. /16/ Dietary protein, U. S. A., = 39% of plant, 61% of animal origin. /17/ Dietary carbohydrate, U. S. A., = 95% of plant, 5% of animal origin. /18/ Dietary fat, U. S. A., = 8% of plant, 92% of animal origin. /19/ Assumed diet contains 27% of carbohydrate as fiber, 73% as NFE. /20/ Maintenance ration for mature cow is usually 100% roughage. Production ration usually 70-75% roughage, 25% concentrates. /21/ Chiefly urea for man, uric acid for chicken. /22/ Calculated from 1.25 urinary Calories per gram of virtually absorbed protein, by 1.25 x 5B and 1.25 x 5C. /23/ Based on urea only. Loss calculated as 2.29 and 3.31 if based on total urinary N. /24/ All Calories in urine attributed to protein metabolites. /25/ Assumed dietary protein = 10% of plant, 90% of animal origin. /26/ Net physiological energy per gram of ingested nutrient.

82. ACCUMULATIVE EFFICIENCY OF FEED UTILIZATION FOR GROWTH: VERTEBRATES

Unless otherwise indicated, values are grams gain in body weight per gram of feed consumed (or pounds gain per pound of feed consumed), calculated by dividing total gain in weight from birth weight to per cent of mature weight stated, by total weight of the feed consumed, including natural moisture content, since birth.

	Species	At Percent of Mature Weight: 10% Male	10% Female	25% Male	25% Female	50% Male	50% Female	90% Male	90% Female
		g of gain/g of feed		g of gain/g of feed		g of gain/g of feed		g of gain/g of feed	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
1	Cattle, dairy, large	0.45	0.54	0.26	0.31	0.17	0.16		0.05
2	Cattle, dairy, small	0.39	0.44	0.33	0.27	0.16	0.20		0.07
3	Cattle, beef	0.62	0.61	0.30	0.25	0.15	0.14		
4	Rat, Sprague-Dawley	0.41		0.31		0.15			
5	Rat, Wistar	0.44		0.34		0.14			
6	Swine[1]	♂♀0.37[2]		♂♀0.27[3]		♂♀0.21[4]			
7	Chicken, white leghorn	0.45[5]	0.45[6]	0.41	0.4	0.33	0.3		0.14
8	Chicken, heavy breeds	0.53[7]	0.54	0.45	0.43	0.35	0.33		0.19
9	Turkey, Beltsville small	♂♀0.46		♂♀0.42		♂♀0.34			
10	Turkey, bronze broad breasted	♂♀0.46		♂♀0.42		♂♀0.34		♂♀0.23	

/1/ Based on 56 day weaning weight and feed consumption figures calculated for three periods: 56-98 days, 98-140 days, and 140-180 days. /2/ Extrapolated. Calculated on basis of mature weight of 600 pounds. 0.39 (extrapolated), calculated on basis of mature weight of 500 pounds. /3/ Calculated on basis of mature weight of 600 pounds. 0.29, calculated on basis of mature weight of 500 pounds. /4/ Extrapolated. Calculated on basis of mature weight of 600 pounds. 0.22, calculated on basis of mature weight of 500 pounds. /5/ Value also reported, 0.48. /6/ Value also reported, 0.45. /7/ Value also reported, 0.44.

83. ABSORPTION, RETENTION, EXCRETION OF NORMAL TISSUE CATIONOGENS: MAMMALS

	Cationogen	Absorption[1]			Retention[2]				Excretion Via[2]		
		Mostly Absorbed	Partly Absorbed	Mostly Unabsorbed[2]	Bone, etc.	In Organs[3]	General Tissues	Extracellular	Urine	Bile	Intestine[4]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Aluminum[5]			+		+			+	+	
2	Calcium		+		++		+		+	+	+
3	Cesium[5,6]	+				+	+		+	+	+
4	Cobalt[6,7]		+			+			++	+	+
5	Copper[7]		+			+			++	+	
6	Iron[6,7]			+		+					+
7	Lithium[5]	+				+	+		++		+
8	Magnesium		+		+	+	+		++	+	
9	Manganese[7]			+	+	++	+			+	+
10	Nickel[5,7]		+			++	+		++		
11	Potassium	+					+		+	+	+
12	Rubidium[5]	+				+	+		+	+	
13	Scandium[5]			+[8]	+		+		+		
14	Sodium	+			+	+	+		++	+	+
15	Tin[5,7]		+			+	+		++		+
16	Titanium[5]			+[8]		+					
17	Zinc[6]			+		+	+		+	+	++

/1/ After oral administration. Mostly absorbed =>70%; partly absorbed = 5-70%; mostly unabsorbed =>5%. Extent of absorption may depend on the amount offered; it is assumed that the various ions are offered in the form of simple soluble compounds, or metallic oxides. /2/ Due to inadequate absorption after oral administration, data on retention and excretion of poorly absorbed elements are from parenteral administration. /3/ Kidney, liver, pancreas, spleen, etc. /4/ Other than in the bile, or by route not definitely established. /5/ Not commonly thought of as normal tissue cationogen, but is present in trace quantities as a result of occurrence in small amounts in animal foods. /6/ Data obtained in part from studies using radioactive isotopes. /7/Valence of two. /8/ Probably, in view of position in the periodic table, and/or, water solubility.

84. ABSORPTION, RETENTION, EXCRETION OF FOREIGN CATIONOGENS: MAMMALS

	Cationogen[1]	Absorption[2]			Retention[3]			Excretion Via[3]			
		Mostly Absorbed	Partly Absorbed	Mostly Unabsorbed[3]	Bone, etc.	In Organs[4]	General Tissues	Expired Air	Urine	Bile	Intestine[5]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Americium			+	++	+	+		+		++
2	Antimony[6]		+			++	+		++		+
3	Arsenic[6]		+		+	+	++	Tr	++		+
4	Barium		+		+				Tr		++
5	Beryllium			+	++	+	+		+		+
6	Bismuth[6]			+	++	++	+		++		+
7	Cadmium[7]			+		+			+		++
8	Cerium			+	+	+					+
9	Chromium			+[8]	++	+			+		
10	Curium			+[8]	++	++	+		+		++
11	Francium	+[8]				+	+		+[8]		
12	Gallium			+	++	+			++		+
13	Germanium[7]	+			+	+	+		++		+
14	Gold[7]			+		+			++		+
15	Lanthanum			+	+	+			+		
16	Lead[8]		+		++	++	+		+	+	+
17	Mercury[7,9]		+			++	+		++	+	+
18	Neodymium[7]			+[8]	+		+				+
19	Neptunium			+	+						
20	Niobium			+			+		+		
21	Palladium[7]			+[8]	+	+	+		++		+
22	Platinum[7]			+[8]		+			++		+
23	Plutonium			+	++	+	+		+		++
24	Polonium			+[8]	++	++	+		+		++
25	Praesodymium			+	+	+					+
26	Promethium			+	+	+					+
27	Protactinium			+[8]	+						
28	Radium		+		+	+			+		++
29	Radium D		+[8]						+		+
30	Ruthenium			+		+					
31	Samarium[7]			+		+					
32	Selenium[7,10]	+				++	+	+	+		
33	Silver			+	+	+	+		Tr	++	
34	Strontium		+		+				++		+
35	Tellurium[10]		+			+		+	+	+	
36	Thallium[7,11]	+				+	+		++		+
37	Thorium			+	+	++			Tr		+
38	Uranium[7,12]		+		+	+[13]			+		
39	Yttrium			+	+	+			++		+
40	Zirconium			+	+						

/1/ Unless otherwise indicated all cationogens used were radioactive, or the data were obtained at least in part from studies using radioactive isotopes. /2/ After oral administration. Mostly absorbed =>70%; partly absorbed = 5-70%; mostly unabsorbed =<5%. Extent of absorption may depend on the amount offered; it is assumed that the various ions are offered in the form of simple soluble compounds, or metallic oxides. /3/ Due to inadequate absorption after oral administration, data on retention and excretion of poorly absorbed elements are from parenteral administration. /4/ Kidney, liver, pancreas, spleen, etc. /5/Other than in the bile, or by route not definitely established. /6/ Valence of three. /7/ Studies made on normally occurring isotopes. /8/ Probably in view of position in the periodic table, and/or, water solubility. /9/ Valence of two. /10/ Valence of four. /11/ Valence of one. /12/ Valence of six. /13/ Retention in liver and kidney for only short periods.

85. ABSORPTION, RETENTION, EXCRETION OF NORMAL TISSUE ANIONOGENS: MAMMALS

	Anionogen	Absorption[1]			Retention				Excretion Via			
		Mostly Absorbed	Partly Absorbed	Mostly Unabsorbed	Bone, etc.	In Organs[2]	General Tissues	Extracellular	Expired Air	Urine	Bile	Intestine[3]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
1	Bicarbonate	+			+	+	+		+	+	+	+
2	Chloride	+			+	+	+	+		++	+	+
3	Fluoride	+			+			+		++		
4	Iodide	+				+[4]	+	+		++	+	
5	Molybdate		+		+	+				++		+
6	Phosphate		+		++	+	+			++	+	+
7	Silicate[5]		+			+				+		+
8	Vanadate	+				+				++		+

/1/ After oral administration. Mostly absorbed =>70%; partly absorbed = 5-70%; mostly unabsorbed =<5%. Extent of absorption may depend on the amount offered. It is assumed that the various ions are offered in the form of simple soluble compounds, or metallic oxides. /2/ Kidney, liver, pancreas, spleen, etc. /3/Other than in the bile, or by route not definitely established. /4/ Highly concentrated in thyroid. /5/ Data obtained in part from studies using radioactive isotopes.

86. ABSORPTION, RETENTION, EXCRETION OF FOREIGN ANIONOGENS: MAMMALS

	Anionogen	Absorption[1]			Retention[2]				Excretion Via[2]		
		Mostly Absorbed	Partly Absorbed	Mostly Unabsorbed[2]	Bone, etc.	In Organs[3]	General Tissues	Extracellular	Urine	Bile	Intestine[4]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Bromide	+				+	+	+	++	+	+
2	Chromate	+				+			++		+
3	Nitrate	+					+		++	+	+
4	Perrhenate			+[5]		+			+		
5	Thiocyanate	+				+	+	+	++	+	+
6	Tungstate		+		+	+			+		

/1/ After oral administration. Mostly absorbed =>70%; partly absorbed = 5-70%; mostly unabsorbed =<5%. Extent of absorption may depend on the amount offered; it is assumed that the various ions are offered in the form of simple soluble compounds, or metallic oxides. /2/ Due to inadequate absorption after oral administration, data on retention and excretion of poorly absorbed anionogens are from parenteral administration. /3/ Kidney, liver, pancreas, spleen,etc. /4/ Other than in the bile, or by route not definitely established. /5/ Probably, in view of position in the periodic table and/or water solubility.

87. CHEMICAL ELEMENTS, FUNCTIONS: ANIMALS

The functions listed in the table require the specific elements noted. In addition, carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur are required for the functions of synthesis of atructural proteins, carbohydrates, fats and other organic compounds, and for formation of end products of metabolism.

Element	Ingestion and Absorption	Distribution	Function	Excretion
(A)	(B)	(C)	(D)	(E)
Bromine	Traces in many foods. Probably completely absorbed from gastrointestinal tract.	Same as chloride in mammals. In Tyrian Purple (=brominated indigo) derived from viscera of marine gastropod (Purpura aperta); in dibromo tyrosine in protein gorgonin from coral (Primnoa lepadifera).	Not known.	Mainly in urine.
Calcium	Almost entirely as salts of inorganic or organic acids. Partial absorption from gastrointestinal tract. Absorption aided by vitamin D and low pH.	Insoluble calcium phosphate complex in bones, teeth in vertebrates. In exoskeleton of numerous invertebrates as calcium carbonate. Minute concentrations as soluble salts in body fluids, all species. As calcium carbonate in shell of certain eggs.	Component of supporting structure in higher forms, many lower forms. Vital electrolyte of cell and extracellular fluid. Protective shell of eggs.	In urine, feces in varying portions.
Chlorine	As for sodium.	Distribution similar to that of sodium, but in general, milliequivalent concentrations are lower. Chief anion of gastric juice. Also present in all other gastrointestinal secretions and all extracellular fluids.	Although principal anion of extracellular fluid, function is unknown. Variation in Cl concentration appears to be better tolerated than in Na and most other electrolytes.	Chiefly in urine. Variable amount in sweat.
Cobalt	Trace constituent of many foods. Absorbed from gastrointestinal tract.	Trace distribution in many tissues, particularly glands and visceral organs, e. g., liver.	Component of vitamin B_{12} (Cobalamin), required by some species from lowest to highest forms. Cobalt deficiency occurs in ruminants as "Pine" disease, salt sickness, bush sickness, "coast" disease. Cobalt enhances activity of certain peptidases.	In urine and feces.
Copper	Minute amounts in food as copper protein complexes. Poorly absorbed from intestine.	Higher concentrations in invertebrates than in vertebrates. Highest concentrations in hepatopancreas and gonads of Mollusca; lowest concentration in muscle. High concentration in gut of insects. Present in turacin (red pigment of feathers of turaco bird). Injected Cu accumulates in liver, kidney. Liver is principal site of storage.	Erythropoiesis. Myelinization of central nervous system. Maintenance of mammalian pigmentation. Trace quantities essential for hemoglobin and possibly iron-porphyrin-protein enzyme synthesis. Constituent of several enzymes present in animal tissues (polyphenol oxidase, tyrosinase, laccase, catechol oxidase, and ascorbic acid oxidase). Component of hemocyanin, respiratory pigment of numerous marine animals; component (cont'd on next page)	Most of orally administered copper appears in feces due to poor absorption. Parenterally administered Cu is slowly excreted, mainly in feces, less in urine.

87. CHEMICAL ELEMENTS, FUNCTIONS: ANIMALS (Continued)

The functions listed in the table require the specific elements noted. In addition, carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur are required for the functions of synthesis of structural proteins, carbohydrates, fats and other organic compounds, and for formation of end products of metabolism.

Element	Ingestion and Absorption	Distribution	Function	Excretion
(A)	(B)	(C)	(D)	(E)
Copper (concluded)			of hepatocuprein, hemocuprein-protein complexes found in liver, blood of certain mammals. Nutritional deficiency disease occurs in cattle, sheep, with inadequate intake or with increased intakes of molybdenum. Molybdenum and copper are mutually antagonistic in ruminant metabolism.	
Fluorine	Traces in various foods, significant quantities in water in certain areas.	Present in bones, teeth. High concentration of 0.6 to 1.6 per cent F in bones of sea animals.	Diminishes solubility of bones and teeth in weakly acid solutions. Decreases caries incidence.	Primarily in urine.
Iodine	Trace amounts in various foods mostly as iodide or as component of organic compounds. Amount in food related to I content of soil. Absorbed from intestine and, in lower forms, through cell membranes.	Principally in thyroid of vertebrates. Component of thyroxin, diiodotyrosine and thyroglobulin. Trace amounts in other tissues. Relatively more iodide in marine fish and other marine animals.	Minute intake essential for growth and for prevention of goiter.	Mainly in urine.
Iron	Mainly as ferrous compounds from gastrointestinal tract. More absorption with iron deficiency states.	In blood hemoglobin, muscle hemoglobin, cytochrome of all cells. Stored in liver and spleen as ferritin (iron phosphoprotein).	Respiratory pigments of higher and lower forms. (Platyhelminthes contain hemoglobin.) Cytochrome is present in practically all cells.	Only traces in excreta. Loss by excretion not more than 1 mg/day except in presence of hemorrhage. Iron in feces is primarily dietary unabsorbed iron.
Magnesium	Widely distributed in foods. Ingested as salt of inorganic or organic acid. Absorbed from intestine.	Minute amounts in plasma and extracellular water. Large amounts in intracellular fluid.	Essential electrolyte. Low concentrations increase cell irritability. Required for activity of several animal enzymes.	Urine and feces.
Manganese	Traces present in most plant and animal foods. Poorly absorbed from gastrointestinal tract.	Particularly in liver, pancreas and hair. Also in all other tissues. Blood pigment of shell fish (Pinna squamosa) contains Mn rather than Fe or Cu.	Component of enzyme arginase. Enhances effect of certain proteinases. Necessary for growth of young animals (rabbits, rats). Also required for proper reproduction in many adult forms. Required for fertility of hen's eggs. Needed to prevent perosis in chicks.	Mainly in feces; traces in urine.

87. CHEMICAL ELEMENTS, FUNCTIONS: ANIMALS (Continued)

The functions listed in the table require the specific elements noted. In addition, carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur are required for the functions of synthesis of structural proteins, carbohydrates, fats and other organic compounds, and for formation of end products of metabolism.

Element	Ingestion and Absorption	Distribution	Function	Excretion
(A)	(B)	(C)	(D)	(E)
Phosphorus	Occurs as phosphate in most foods. Absorbed from gastrointestinal tract in higher forms. Absorbed through cell membranes in lower forms.	Large quantities as phosphate complex of calcium in bone of vertebrates. Component of phospholipids (nerve and other tissues), phosphocreatine or phosphoarginine (muscle); as inorganic PO_4 in cell, extracellular fluid; as nucleoprotein in all tissues; and as adenosine triphosphate (ATP) in variety of cells of higher and lower species. Intracellular inorganic phosphate low relative to phosphate esters.	Important structural component of bone. Component of high energy P compounds (ATP, phosphocreatine, phosphoarginine, acetyl phosphate). Combines with intermediates in carbohydrate metabolism. Buffer in urine. Constituent of nucleoprotein. Component of phospholipids (intermediates in lipid metabolism).	Excreted in urine and feces.
Potassium	Ingested as inorganic salt in variety of foods. Absorbed from intestine. Absorbed through gills and cell membranes in many lower marine forms.	Principal cation of intracellular water. Small amount in extracellular water.	Essential cation of intracellular fluid.	Almost entirely in urine. Minute amounts in feces and sweat.
Silicon	Absorbed from intestine. Inhaled particles deposit in lungs and give rise to serious effects. Absorbed through cell membrane of lower forms.	In skeletal structures and in supporting structures of certain Protozoa, Poriphera and higher forms.	Protective and structural component of various lower animal forms.	Primarily in urine of vertebrates.
Sodium	Widely distributed in foods as inorganic salt. More in foods of animal origin than in foods of plant origin. Taken as NaCl by many higher vertebrates including man. Absorbed from intestine in higher forms and through gills and cell membranes in lower forms.	Major part of body sodium is extracellular, much in bone. Some intracellular. Tissues vary in concentration of intracellular sodium, muscle containing only small amounts. Data on other than mammalian forms not available.	Chief cation of extracellular water. Essential for proper external environment of cells. Chief cation of intestinal secretions. Salts are important buffers of plasma, extracellular water and urine.	Primarily in urine. Variable quantities in sweat. Small amounts in feces.
Sulfur	As inorganic sulfates, organic sulfates and sulfhydryl sulfur of cystine and methionine.	Small amount of sulfate in extracellular H_2O. Relatively large amount in proteins and small amount in certain lipids.	Essential component of many proteins. Sulfuric acid secreted as digestive fluid in Ascidia. Sulfate is important anion in intracellular fluid. Sulfate used in detoxification reactions.	Mostly in urine as sulfates and sulfhydryl compounds.
Vanadium	Extracted from marine muds by Ascidia.	In blood respiratory pigment of marine worm, Ascidia.	Component of respiratory pigment which provides oxygen transport in Ascidia.	Mostly in feces.

87. CHEMICAL ELEMENTS, FUNCTIONS: ANIMALS (Concluded)

The functions listed in the table require the specific elements noted. In addition, carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur are required for the functions of synthesis of structural proteins, carbohydrates, fats and other organic compounds, and for formation of end products of metabolism.

Element	Ingestion and Absorption	Distribution	Function	Excretion
(A)	(B)	(C)	(D)	(E)
Zinc	Traces present in most foods. Absorbed from gastrointestinal tracts; in lower forms through cell membrane.	Largest quantities in pancreas, hair, nails, bone. Very large concentrations in certain oysters and in herring.	Prosthetic group of carbonic anhydrase. Indispensable for nutrition of growing rat. Also required by adult for reproduction. Needed for activation of certain proteinases.	Mainly by feces.

88. TRACE ELEMENTS, FUNCTIONS: ANIMALS

Element	Biologically Important Compounds or Ions	Metabolic Role	Deficiency Manifestations	Toxic Manifestations	Quantitative Considerations	
					Normal Levels or Requirements	Toxic Levels
(A)	(B)	(C)	(D)	(E)	(F)	(G)
Cobalt	Vitamin B_{12}. Vitamin B_{12a} or b. Vitamin B_{12c}.	Growth promotion (B_{12}, chick). Production of labile methyl groups and transmethylation. Synthesis of ribonucleic acid.	Lethargy, wasting, inanition, anemia, fatty liver, death (sheep, cattle). Addisonian type pernicious anemia (man). Demyelination: combined system disease (man).	Polycythemia (rat and other mammals, birds, and amphibia). Death (rat). Degeneration of alpha cells of pancreatic islets.	3.0 μg vitamin B_{12}/day in pernicious anemia.	50 mg Co^{++}/kg body wt/day (growth failure in rat).
Copper	Hemocyanin. Tyrosinase. Ascorbic acid oxidase. Hemocuprein. Hepatocuprein. Transferrin. Turacin.	Respiratory pigment (Mollusca and Arthropoda). Keratinization, pigmentation of hair. Myelinization of nerve. Erythropoiesis. Iron metabolism.	Achromotrichia and impairment of keratinization. Anemia. Hemosiderosis. Cachexia. Inhibition of growth. Ataxia. Cardiac decompensation. Eventually death (all above symptoms observed in cattle and sheep). Microcytic, hypochromic anemia (rabbit, sheep).	Hemolytic crises. Jaundice. Hemoglobinuria. Death (sheep, cattle).	94 ± 10 μg/100 ml blood (man). 2 mg/day, daily requirement (man). 10 mg Cu/day, according to Mo^{++} and $SO_4^{=}$ in diet (sheep). 100 μg Cu/100 ml blood (sheep, cattle).	20-50 mg Cu/day causing excess storage, which may result in death (sheep). 8.3 mg Cu as chloride, lethal dose (rabbit). 200-400 g Cu as sulfate, lethal dose (cattle).
Fluorine	F^-	No evidence that it is essential. Optimum amount in teeth is associated with resistance to caries.		Acute gastroenteritis, vomiting, pain, and diarrhea (man). Marked fall in blood pressure (man). Convulsions. Mottled enamel (man). Osteosclerosis (man). Growth inhibition (rat). Disturbance of ovarian, pituitary, and thyroid function (rat). Phosphatase inhibition. Esterase inhibition. Enolase inhibition.	1.0-2.0 p.p.m. F^- in H_2O will reduce caries in children.	0.5 g/kg body wt orally, acute dose (mammals). 3.0-4.0 p.p.m. F^- in H_2O (production of mottled enamel rat).

88. TRACE ELEMENTS, FUNCTIONS: ANIMALS (Concluded)

Element	Biologically Important Compounds or Ions	Metabolic Role	Deficiency Manifestations	Toxic Manifestations	Quantitative Consideration	
					Normal Levels or Requirements	Toxic Levels
(A)	(B)	(C)	(D)	(E)	(F)	(G)
Iodine	I^- Monoiodotyrosine. Diiodotyrosine. Thyroxine. Thyroglobulin. 3,5,3 triiodothyronine.	Promotion of growth and development. Maintenance of normal metabolic rate. I^-; resorption of inflammatory lesions.	Cretinism or myxedema (children). Myxedema (man). Goiter.	Hyperthyroidism, excess thyroxine. Angioneurotic edema, excess I^-. Iodism causing salivation, coryza, skin lesions, headache, bloody diarrhea.	3 μg I^-/kg body wt, daily requirement. 4.45 μg%, normal whole blood iodine.	
Iron	Hemoglobin. Myoglobin. Cytochromes. Cytochrome oxidase. Catalase. Ferritin. Verdoperoxidase.	Transportation of O_2 and CO_2. Redox catalysis. Dissociation of H_2O_2.	Fatigue and listlessness. Sore tongue. Angular stomatitis. Dysphagia. Koilonychia. Microcytic, hypochromic anemia (man).	Gastroenteritis, acute hemorrhagic gastritis, liver damage caused from oral administration of ferrous sulfate. Flushing, nausea and vomiting, lacrimation, and paresthesia caused from intravenous administration of ferrous sulfate. Hemochromatosis caused by excessive absorption not normal intake due to a metabolic abnormality.	♂12 mg orally daily (man). ♀15 mg orally daily (man). ♂100-150 μg%, ♀90-150 μg%, serum iron levels.	6-10 g ferrous sulfate orally. 1/2g colloidal ferric hydroxide or oxide intravenously.
Manganese	Mn^{++}	Essential for normal reproduction, lactation, bone formation, and growth. Arginase activation. Leucylpeptidase activation. Oxalacetic carboxylase activation. Phospboglucomutase activation. Phosphatase activation. Function in choline metabolism.	Growth impairment (rabbit, rat, mouse). Congenital debility (rat). Sterility with testicular atrophy and estrus cycle irregularity (rat, rabbit). Skeletal abnormalities (rat, chick, rabbit). Perosis (chick)	Parkinsonian-like disturbance of speech and gait, muscular weakness, tremor, and loss of sexual vigor (man). Liver damage.	♂0.17 μg%, ♀0.15 μg%.	
Zinc	Carbonic anhydrase. Zinc uroporphyrin. Zinc coproporphyrin. Hemosycotypin. Zinc-melanin. Zn^{++} Zinc protein.	Catalysis of the reaction: $CO_2 + H_2O \rightleftarrows H_2CO_3$ for release of CO_2 at the lung alveoli; for uptake of CO_2 at the tissue cells; for the production of HCL in the gastric mucosa and for renal tubular control of urinary pH. Blood respiratory pigment of the snail. Activator of leucyldiglycinase.	Growth inhibition, cachexia, posterior column disease (mouse). Achromotrichia. Eczema and alopecia (rat). Elevation of blood uric acid, reduced blood alkaline phosphatase, low pancreatic amylase (rat).	Metal fume fever (man). Anemia (rat).	8.8 ± 2 μg per ml whole blood (man).	2 mg/kg body wt as Zn gluconate (man).

89. THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES

VITAMIN A (Anti-xerophthalmia factor, axeropthol)

Required by all vertebrates studied, including man, cattle, dog, guinea pig, hedgehog, horse, monkey, rabbit, rat, chicken, turkey. May be formed within the organism from one of the carotenoid provitamins, alpha-, beta-, gamma-carotene, or cryptoxanthin. Exists as vitamin A_1 in marine fishes and land vertebrates, as both A_1 and A_2 in amphibia and anadromous and catadromous fishes, and as A_2 (in place of or in addition to A_1) in fresh water fishes.

Functions	Signs of Deficiency[1,2]	Signs of Excess[3]
(A)	(B)	(C)
Stimulates growth and development to normal. (Man, pig, rat, others). Maintains the health of epithelium. Vitamin A (primary alcohol, $C_{19}H_{27}CH_2OR$) is a precursor for retinene (corresponding aldehyde $C_{19}H_{27}CHO$) which, with the visual proteins ("opsins"), forms the photosensitive visual pigments (rhodopsin, porphyropsin, iodopsin). Diphosphopyridine nucleotide (contains nicotinamide, q.v.) and retinene reductase (alcohol dehydrogenase) are involved in the reactions.	General: Retarded growth of young (Man, rat, chick, turkey); inability to stand on hind legs (Pig). Bone: Localized overgrowth (Cattle, rat). Eye: Retina--synthesis and regeneration of visual pigments decreased; night blindness; visual acuity impaired; photophobia (Man). Cornea, sclera, lacrimal glands and ducts, conjunctiva--degenerative changes as with other epithelium (q.v.); may lead to xerophthalmia, keratomalacia in severe deficiency (Man, rat). Epithelium: Skin (Man, rat) and mucosae (Man), particularly of upper respiratory tract, sinuses, bronchii, broochioles, genitourinary tract--metaplasia, hyperkeratinization, cornification, desquamation, varying in degree with severity and duration of deficiency. Neural: Optic nerve degeneration, possible result of skull overgrowth and pressure (Cattle, rat). Reproduction: Decreased egg production (Chicken); irregular estrus--sterility, male (Rat). Teeth: Odontoblast atrophy (Man, rat).	Blood: Hypoprothrombinemia (Rat); increased serum lipids, phosphatase; decreased serum proteins (Man). Bone: Fragility, hyperostosis, cortical thickening of long bones, periosteal swellings, pain (Man). Epithelium: Dryness, exfoliation; hair sparse and rough; mouth desquamation, hyperemia of skin and mucosae (Man). Liver: Enlargement (Man). Vascular: Telangiectasis.

ASCORBIC ACID (Vitamin C; anti-scorbutic factor)

Required by man and other primates, guinea pig.

Functions	Signs of Deficiency[1,4]	Signs of Excess
(A)	(B)	(C)
Protects adrenal oxy-steroids from destruction by liver (Rat). As an anti-oxidant protects hydrogen carriers. Promotes oxidation of fatty acids; participates in oxidation of aromatic amino acids. Promotes conversion of folic acid to folinic acid. Essential for formation of intercellular substances: collagen, ossein, dentine. Increases phagocytic activity. Prevention and treatment of scurvy (Primates, guinea pig). Alleviates some effects of vitamin A lack and moderate excess; in large amounts alleviates effects of thiamine and pantothenic acid (cont'd next page)	General: Loss of appetite, decline in physical activity; retarded, defective wound healing; general weakness in organs with high content of intercellular substance and particularly those with a high calcium content. Skin, hair: Follicular keratosis (Man); loss of luster, roughening of fur and hair. Bone: Disorientation of cells in growing region; beading of ribs; failure of chondroblast and osteoblast differentiation and maturation. Teeth: Disorientation of cells in growing region; failure of differentiation and maturation of ameloblasts (enamel organ); loosening of teeth in their sockets (Primates); swollen gums. Hematopoiesis: Anemia with decrease in red cells and hemoglobin; increase in circulating leukocytes. Fibroblasts: Failure of differentiation and maturation. Vascular: Capillary hemorrhages, particularly in subcutaneous and intra-muscular areas. Muscle: Swelling, atrophy, waxy degeneration of skeletal muscle; soreness of muscles leading to assumption of "face ache posture." Adrenals: Increase in cholesterol content in early deficiency, decrease in late deficiency. Other effects: Reduction of cytoplasm and indistinctness (cont'd next page)	Hypervitaminosis doubtful if calcium content of diet is sufficient. Massive doses by injection lead to sudden death.

/1/ Deficiency signs, when not irreversible, may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /2/ Some causes of deficiency signs, other than dietary deficiency of the vitamin, are: any factor impairing digestion or absorption of fat, as inflammation of intestinal mucosa, sprue (cf. Folic acid), or chronic diarrhea; excessive ingestion of mineral oil; hyperthyroidism (inhibits conversion of provitamins to vitamin A_1). /3/ Wide margin of safety between amounts recommended for normal intake, prophylaxis, and therapeutic use. /4/ Summation of deficiency effects makes up the syndrome of scurvy which may vary in extent and degree with extent of deficiency.

89. THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Continued)

Ascorbic Acid (Concluded)

Functions	Signs of Deficiency[1]	Signs of Excess
(A)	(B)	(C)
lack (Rat); prevents development of deficiency signs on Vitamin E deficient diets (Chick, guinea pig). Treatment of shock, wounds, infections.	of cell membrane, increased respiration rate early in deficiency, decrease in late stages; lowering of temperature in late stages.	

BIOTIN

(Anti-egg white factor; vitamin H; coenzyme R; factor S; factor W; factor X; bios IIG)

Probably required by most or all vertebrates. The need for the vitamin may be met under normal circumstances by intestinal bacterial synthesis. Need demonstrated for man, calf, dog, monkey, mouse, rabbit, rat, chicken, turkey.

Functions	Signs of Deficiency[5]	Signs of Excess
(A)	(B)	(C)
A fundamental growth factor for all vertebrates? Believed to be required by all rapidly growing tissues. Involved in such metabolic processes as: carboxylation and decarboxylation of Krebs Cycle acids; deamination of aspartic acid, serine, threonine; synthesis of citrulline; synthesis of unsaturated fatty acids. Improves lactation (Rat).	Skin: Seborrheic skin pathology. Scaly, greasy dermatitis (Dog, monkey, rat, rabbit, chicken) followed by extreme hyperkeratosis after long deficiency. Scaly dermatitis after a period of heavy intake of dried egg white has been demonstrated in volunteers fed 200 grams of egg white daily (Man). Skin appendages: Spectacle alopecia (baldness around eyes: rodents); alopecia (loss of hair; monkey) may be extreme. Oral tissues: Atrophy of lingual papillae (Man). Neuromuscular: Spasticity (Rat); paralysis of hind quarters (Rat). Cardiac: Precordial distress; electrocardiographic changes (Man). Other: Anorexia, lassitude, sleeplessness, muscle pain (Man).	Sufficiently detailed and critical studies not yet made.

CHOLINE

(No single compound analogous to choline can carry out all of the functions of the vitamin, although several compounds can replace choline in one or more of its functions.)

Required by most or all vertebrates, especially the young including dog, guinea pig, rat, chicken, turkey.

Functions[6]	Signs of Deficiency	Signs of Excess
(A)	(B)	(C)
Source of transferable (labile) methyl (CH_3) groups in metabolism. Before acting as methyl donor, choline is enzymatically transformed to betaine which transfers the methyl group. May be readily replaced as a methyl donor by betaine, dimethyl thetine, or (cont'd next page)	General: Increased mortality (Chicken, turkey). Liver: Fatty degeneration, cirrhosis (Dog, rabbit, rat); prolonged prothrombin and bromsulphalein times, changes being marked in animals on high protein diets (Rat); liver carcinoma from chronic deficiency (Mouse, rat, chicken). Blood serum: Increased serum phosphatase (Rat). Kidney: Enlargement, hemorrhagic congestion, necrosis of renal tubule, epithelium and glomeruli (Rat); granular atrophy; hypertension in consequence of early kidney lesions, decrease in alkaline phosphatase activity and fat deposition (Rat). Nervous system: Paralysis (Young rat). (cont'd next page)	Hematopoiesis: Inhibition of erythrocyte formation (Dog). Digestive system: Diarrhea (Man). Vascular: Edema of legs (Man).

/1/ Deficiency signs, when not irreversible, may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /5/ Spontaneous deficiency is extremely rare, although reported for the chick. Feeding of raw egg white (active agent, avidin) is necessary to produce deficiency signs in animals. Avidin and biotin form a complex in the intestine which renders the vitamin unavailable to the organisms. /6/ The following therapeutic uses of choline have been noted: cure of fatty liver and certain forms of liver cirrhosis (dog, rat); prevention of perosis ("slipped tendon" (chicken, turkey)).

89. THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Continued)

Choline (Concluded)

Functions	Signs of Deficiency	Signs of Excess
(A)	(B)	(C)
methionine. Donor of methyl groups[7] for synthesis of methionine (in presence of homocysteine), purines, etc.	Reproduction; Decreased egg production, ovarian abortion (Chicken, turkey). Vascular: Intracranial bleeding in young, born of choline deficient females (Rat).	
Synthesis of phospholipids, i. e., lecithin. Participates in creatine formation (Rat). Precursor of acetylcholine. Essential for normal nutrition and egg production (Chicken). Essential for lactation (Hamster, rat). Necessary for normal liver function (Dog, mouse, rat, chicken). A direct catalytic role of choline in intermediate metabolism has not been demonstrated.		

COBALAMIN[8]

(Vitamin B_{12}; vitamin B_{12a}; vitamin B 12b; cyanocobalamin; hydroxycobalamin)

Required by most or all vertebrates studied.

Functions[9]	Signs of Deficiency[1]	Signs of Excess
(A)	(B)	(C)
General growth factor (Man, mouse, rat, swine, chicken, turkey). Utilization of orally administered cobalamin is potentiated by gastric juice; this suggests the presence of an "intrinsic" factor necessary for the utilization of cobalamin, the "extrinsic" factor. In methylation reactions (Rat, chick). Combined action with folic acid group.	Hematopoietic tissue: Megaloblastic bone marrow (Man). Blood: Macrocytic, hyperchromic anemia (Man). Neural: Degenerative changes in the spinal cord. Oral tissue: Glossitis (Man).	Polycythemia of non-ruminant animals has been reported.

VITAMIN D

(Anti-rachitic factor; calciferol; vitamin D_2; 7-dehyrocholesterol, vitamin D_3)

Required by most or all vertebrates studied. Under the influence of ultraviolet light, the vitamin may be formed from ergosterol (a vegetable sterol, precursor of D_2), or 7-dehydrocholesterol (an animal sterol, precursor of D_3).

Functions	Signs of Deficiency [1,10]	Signs of Excess[11]
(A)	(B)	(C)
Essential to normal development of bone. Enhances net absorption and retention of Ca and P; reduces excretion of P in feces; promotes P reabsorption by the renal	General: Retardation of growth (Man, others). Bone: Rickets. Skeletal abnormalities and deformities[12] varying with degree and duration of deficiency (Man, rat, others). Rapidly growing regions are most affected, e.g., junction of epiphysis and diaphysis, long bones; areas of proliferation, flat bones. Irregular, disordered growth pattern, deficient calcification; persistent over-proliferation of cartilage; persistent irregular calcification of osteoid matrix; enlargement of ends of long bones; softness, weakness of bones, and deformation by	General: Early symptoms are anorexia, thirst, lassitude, urinary urgency with or without polyuria. Later symptoms are nausea, vomiting, diarrhea, abdominal discomfort leading to weight loss and debility.
(cont'd next page)	(cont'd next page)	(cont'd next page)

/1/ Deficiency signs, when not irreversible, may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /7/ Some synthesis of CH_3 occurs in the metabolism of glycine, alanine, serine, histidine, tryptophan. /8/ Probably identical with the anti-pernicious anemia principle of liver. /9/ The following therapeutic uses of cobalamin have been noted: Treatment of pernicious anemia--the vitamin is anti-anemic, relieves the lingual manifestations and reverses the degenerative changes in the spinal cord unless damage is irreversible (Man); treatment of sprue (Man). /10/ Some causes of deficiency signs, other than dietary deficiency of the vitamin, are: any factor impairing digestion or absorption of fat, as inflammation of intestinal mucosa, sprue, or chronic diarrhea; excessive ingestion of mineral oil; relatively greater requirement during pregnancy and lactation. /11/ The amount of dietary vitamin D which will produce signs of excess varies with individuals within the same species, and at different times within the same individual. /12/ Skeletal abnormalities and deformities are the scars and residue of functional and structural change and may persist long after the deficiency has been relieved. Degree of restoration may be extensive and continue over long periods.

89. THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Continued)

Vitamin D (Concluded)

Functions	Signs of Deficiency[1]	Signs of Excess
(A)	(B)	(C)
tubules. Maintains alkaline phosphotase at the bone site. The vitamin is particularly effective during the period of rapid skeletal growth.	stress and posture; increased thickness of bone shaft; osteomalacia: decalcification, fragility of non-growing bone. Teeth: Faulty calcification, most frequent in the permanent dentition; defects difficult to distinguish from deficiencies of vitamins A and C. Mineral metabolism: Hypocalcemia, hypophosphatemia; derangement of Ca and P deposition in bone matrix and teeth. Blood plasma: Increase in plasma phosphatase. Muscle: Myasthenia; atony, skeletal and gut muscle. Neuromuscular: Tetany, convulsions, spasmodic closure of glottis (Man, rat).	Blood: Hypercalcemia, hyperphosphatemia. Mineral Metabolism: Deposition of Ca salts in various organs, arteries and arterioles; metastatic calcification may occur without hypercalcemia in the dog. Bone: Dense calcification in zone of provisional calcification in long bone metaphyses at the expense of diaphyseal calcification, in infants and growing young (Man). Renal: Ca deposits with resulting kidney damage and renal dysfunction; increased urinary excretion of Ca and P. Other: Continued hypervitaminosis leads to death. Since vitamin D is stored, excessive doses may be cumulative. Hypercalcemia, high urinary Ca and renal damage have been noted eight months after treatment (125,000-unit doses daily).

VITAMIN E[1]

(Alpha-, beta-, delta-, gamma-tocopherols; anti-sterility factor)

Required by cattle, dog, guinea pig, hamster, mink, mouse, rabbit, rat, swine, chicken, duck, turkey. Significance, if any, in human nutrition, has not yet been established.

Functions[13]	Signs of Deficiency[10]	Signs of Excess
(A)	(B)	(C)
Biological anti-oxidant; protects unsaturated fatty acids, vitamin A against peroxidation. Participates in oxidation-reduction reactions.	Reproductive organs: Irreparable degeneration of the testicular germinal epithelium; testicular degeneration with decrease in weight of testes (Bull, mouse, rat, chicken); uterine necrosis, seminal vesicle necrosis (Rat). Reproduction: Resorptive failure of pregnancy after death of the fetus, in severe deficiency; prolonged gestation with still-birth or death postpartum of the newborn, in moderate deficiency (Rat). Reproductive failure (Swine). Reduced egg hatchability, death of the embryo (Chicken). Muscular: Acute muscle degeneration with swelling, hyalinization, necrosis of striated muscle and (in some species) cardiac muscle (Dog, guinea pig, hamster, rabbit, rat, chicken, duck). Isolated degeneration of smooth muscle of gizzard (Turkey). Neural: Acute encephalomalacia, degeneration of the cerebellum, nerve cell degeneration (Chick). Neuromuscular: Ataxia, tremors, weakness, opisthotonos (retraction of head--chicken). Paralysis (suckling rat, born of vitamin E deficient mother). Urine: Creatinuria. Vascular: Generalized exudative diathesis (Chick). Liver: Necrosis, degeneration (Mouse, rat, swine). Metabolic: Increased oxygen uptake, in vitro, of muscle tissue from vitamin E deficient individuals (Hamster, rabbit, rat).	

/1/ Deficiency signs, when not irreversible, may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /10/ Some causes of deficiency signs, other than dietary deficiency of the vitamin, are: any factor impairing digestion or absorption of fat, as inflammation of intestinal mucosa, sprue, or chronic diarrhea; excessive ingestion of mineral oil; relatively greater requirement during pregnancy and lactation. /13/ The following therapeutic uses for vitamin E have been noted: treatment of skin collagenoses (man); protects against nutritional encephalomalacia (chick); experimentally protects against such toxic agents as carbon tetrachloride, chloroform, alloxan; cures and prevents the muscle lesions which develop in young of vitamin E deficient mothers (guinea pig, hamster, rabbit, rat, duckling) and of older rat on vitamin E deficient diets.

89. THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Continued)

FOLIC ACID GROUP

(Folacin; pteroylglutamic acid (PGA); folinic acid; citrovorum factor; vitamin M; vitamin B_c; vitamin B_{10}; factor U; L. casei factor; Norite eluate factor)

Required by most or all vertebrates studied, except ruminants and others whose need is satisfied by intestinal bacterial synthesis. The essentiality of the vitamin to man, dog, guinea pig, fox, mink, sulfa-treated lamb and rat, chicken, duck, goose, turkey, fish, is established.

	Functions[14] (A)	Signs of Deficiency[1] (B)	Signs of Excess[15] (C)
150	An essential growth and hematopoietic factor (Monkey, fox, mink, chick, on purified rations). Production and utilization of formate.	General: Retardation of growth. Blood, hematopoietic tissues: Sprue (Man, monkey); megaloblastic bone marrow (Man, monkey, others), macrocytic, hyperchromic anemia (Man, monkey); macrocytic anemia, with ultimate anisocytosis (Chick, turkey); Cytopenia (Monkey, chick); leukocyte abnormalities (Monkey, rat, chick); infarction of the spleen (Rat). Skin, skin appendages: Poor feather structure (Chicken, turkey); abnormal feather pigmentation (Chicken); graying of the pelage (Rat). Bone: Perosis ("slipped tendon"--Chicken, turkey) Reproduction: Impaired reproduction (Rat, chicken); lowered hatchability of eggs (Chicken). Mammary gland: Impaired lactation (Rat). Development: Hydrocephalus (Rat). Neuromuscular: Neck paralysis (Goose, turkey). Intestinal: Diarrhea and the absorptive difficulties associated with the syndrome of sprue (disorders of calcium metabolism; impaired absorption of fat and of fat soluble and water soluble vitamins).	Relatively non-toxic. Males more resistant than females (Mouse). Death by obstruction of the renal tubules with precipitated folic acid follows intake of toxic amounts.
155	Methylation reactions, e.g., ethanolamine to choline, homocysteine to methionine, nicotinamide to N-methylnicotinamide, pyrimidine		
160	ring to thymine. Introduction of the 2- and 8-carbon atoms into the purine ring and the amidine carbon into histidine.		
165	Tyrosine oxidation.		

INOSITOL (MESO-)

(Mouse anti-alopecia factor; Bios I)

Required by mouse and possibly cotton rat and hamster.

	Functions (A)	Signs of Deficiency (B)	Signs of Excess (C)
170	Stimulates growth when added to rations deficient in thiamine (Rat) and to rations containing sulfonamides (Rat, swine).	Skin and skin appendages: Characteristic alopecia (loss of hair--Mouse); severe dermatitis following alopecia (Mouse).	Non-toxic, as far as known
175	Lipotropic factor essential in metabolism of fat and cholesterol. Active, with choline, in preventing some types of fatty liver (Rats). Prevents encephalomalacia and exudative diathesis in vitamin E deficiency (Chicken). Suggested essential to reproduction (Hamster).		

PARA-AMINOBENZOIC ACID ("PABA")

Required by: None?

	Functions (A)	Signs of Deficiency (B)	Signs of Excess (C)
180	The vitamin-like action in vertebrates can probably be entirely explained by the action of folic acid (q.v.) of which it is a structural component.		

/1/ Deficiency signs, when not irreversible, may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /14/ The following therapeutic uses of the vitamin have been noted: Treatment of sprue (man); nutritional macrocytic anemia; certain megaloblastic, macrocytic anemias of infancy (man); macrocytic anemia of pregnancy (man); added to practical rations as a growth stimulation factor (mink). Folic acid antagonists, e.g., aminopterin, used in treatment of leukemia and certain other diseases (man). /15/ Intravenous LD_{50}=600 mg/kg body weight (mouse); 500 mg/kg (rat); 410 mg/kg (rabbit); 120 mg/kg (guinea pig).

89. THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Continued)

VITAMIN K
(Anti-hemorrhagic factor; phylloquinone)[16]

Required by man, dog, mouse, rabbit, rat, canary, chicken, duck, goose, pigeon, turkey. In mammals, bacterial synthesis may satisfy the need in whole or in part, and demonstration of essentiality depends on rigid control of bacterial synthesis.

Functions[17]	Signs of Deficiency[1,10,18]	Signs of Excess
(A)	(B)	(C)
Essential for the production of prothrombin[19]; (the vitamin itself does not enter into the structure of the prothrombin molecule).	Liver: Decline or failure of prothrombin synthesis. Blood: Decrease in blood prothrombin content, resulting in: increased bleeding tendency after even slight trauma; multiple hemorrhages throughout all tissues (Man, chicken); increased clotting time (Man, others).	Gastrointestinal: Vomiting (Man); vomiting after oral dose of 180 mg of menadione (synthetic vitamin) (Dog). Urine: Porphyrinuria (Man, dog); albuminuria (Dog). Blood: Prolonged clotting time (Rabbit); cytopenia, hemoglobinemia (Mouse).

NIACIN (-AMIDE)
(Nicotinic acid (-amide); pellagra preventive (P.P.) factor; anti-blacktongue factor).

Required by all vertebrates studied except calf, horse, sheep, whose need is supplied by intestinal flora. The rat, chicken, turkey and other animals are able to synthesize niacin from tryptophan. Animal tissues contain the vitamin almost exclusively as niacinamide; plant tissues contain it mainly in the form of niacin.

Functions	Signs of Deficiency[1,20]	Signs of Excess[21]
(A)	(B)	(C)
A component of di- and triphosphopyridine nucleotides (DPN, Coenzyme I; TPN, Coenzyme II) which function as hydrogen acceptors in more than 50 metabolic reactions. DPN catalyzes the conversion of vitamin A_1 to rhodopsin, and retinene to vitamin A. Stimulates gastric secretion. The vitamin is synergistic with folic acid.	General: Delayed growth and development of young; lowered oxidation rate in some tissues; dermatitis, diarrhea, and dementia (the triad of pellagra). Epithelium: Bilateral, symmetrical dermatitis, aggravated by sunlight, heat, inflammation (Man, only); rarefaction of corium, keratinization, atrophy of sebaceous glands, desquamation. Swollen gills (Trout). Poor feathering (Chick). Digestive tract: Stomatitis (Man, dog, fox, swine, chicken, turkey); smooth glossitis (Man); blacktongue (Dog, cat, chicken); large intestine--atrophy, ulceration, cyst formation (Man, dog, swine); diarrhea (Man, dog, calf, rabbit, chicken, duck, turkey); achlorhydria (Man, swine); salivary drooling (Dog). Hematopoietic: Macrocytic anemia (Man, dog, rabbit, swine); leukopenia (Dog, rabbit). Neural: Degenerative changes (Man, dog); retrobulbar neuritis (Man); encephalopathy, headache, dizziness, depression, delusions, dementia; locomotor difficulties, tremors, jerky movements, rigidity; altered tendon reflexes, numbness, paralysis (Man). Bone: Perosis ("Slipped tendon"--Chick, turkey poult).	General: Death follows very large doses; dogs on 2 grams/day die within 20 days; 2% niacinamide in diet inhibits growth (chick); 1% causes fatty livers; large doses of niacin cause ketosis (Rat). Epithelium: Burning and itching of skin; elevation of skin temperature (Man). Vascular: Peripheral vasodilation (Man). Neural: Paralysis of the respiratory center (Rat).

/1/ Deficiency signs, when not irreversible, may be alleviated, and the animal restored to health by the administration of therapeutic doses of the vitamin. /10/ Some causes of deficiency signs, other than dietary deficiency of the vitamin, are: any factor impairing digestion or absorption of fat, as inflammation of intestinal mucosa, sprue, or chronic diarrhea; excessive ingestion of mineral oil; relatively greater requirement during pregnancy and lactation. /16/ A number of synthetic products having a quinoid nucleus have vitamin K activity, e.g., menadione (2-methyl-1,4-naphthoquinone). The synthetics tend to be more toxic (in excessive amounts) than the naturally occuring vitamin. /17/ The following therapeutic uses of the vitamin have been noted: stimulation of prothrombin production; reduction of prothrombin clotting time. Ineffective in treatment of hemorrhagic diseases not due to prothrombin deficiency, e.g., hemophilia, thrombocytopenia. In hypoprothrombinemia of the newborn, prevention and treatment (man). Counteracts effects of dicumarol (man, others). /18/ Vitamin K deficiency does not precipitate bleeding; the abnormality is failure of clotting after bleeding has begun. /19/ The prothrombin stimulating properties of vitamin K act through the site of prothrombin production (liver), and the vitamin, even in large amounts, is ineffective if the prothrombin producing tissues are damaged or impaired. /20/ The syndrome of deficiency symptoms is referred to as "Pellagra" in man and "blacktongue" in dogs, cats, and other animals. /21/ Ratio, therapeutic dose: toxic dose = 1:1000.

89. THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Continued)

PANTOTHENIC ACID

(Pantothen; filtrate factor; chick anti-dermatitis factor; chick anti-pellagra factor; factor II; anti-chromotrichia factor; anti-gray hair factor)

Required by most or all vertebrates studied, including calf, dog, fox, guinea pig, hamster, monkey, mouse, swine, rat, chicken, duck, pigeon, turkey.

Functions[22]	Signs of Deficiency	Signs of Excess[23]
(A)	(B)	(C)
Growth factor for the animals mentioned above. As a component of Coenzyme A functions in: enzymatic acetylation; fat, protein, carbohydrate metabolism; phospholipid and steroid synthesis.	General: Retarded growth. Skin: Specific dermatitis of mouth and feet (Chicken); eczematous dermatitis (Rat). Hair: Achromotrichia (graying) (Monkey, dog, fox, rat, mouse); spectacle alopecia (Rat). Tongue: Ulceration (Rat). Neural: Myelin degeneration of peripheral nerves (Chick); chromatolysis of dorsal root ganglion cells (Chick, swine). Neuromuscular: Spastic abnormalities of hind quarters, abnormal gait, ataxia (Dog, mouse, swine); convulsions (Dog). Endocrine glands: Hemorrhagic necrosis of adrenals. Exocrine glands: Secretion of red pigment by the Harderian gland ("bloody pigment"--Rat). Gastrointestinal: Diarrhea with bloody stools (Dog); anorexia, diarrhea, colitis (Monkey, swine); necrosis of intestinal epithelium, abscesses followed by ulceration (Rat). Hematopoiesis: Anemia (Dog, rat, monkey, swine). Kidney: Necrosis (Rat). Liver: Increased deposition of fat (Dog, chick). Other: Burning sensations of hands, feet (Man); collapse associated with decreased blood glucose and blood chloride; increased non-protein nitrogen in severe deficiency (Dog); death in severe deficiency.	100 grams may be given to man intravenously without ill effects.

PYRIDOXINE (VITAMIN B_6) GROUP[24]

(Pyridoxal, pyridoxamine, pyridoxine; anti-acrodynia factor; factor Y)

Required by most or all vertebrates studied, including man; synthesized by intestinal organisms in rat. Requirement by animals is increased with increased dietary protein, methionine, linseed oil, sucrose, and apparently decreased with increased dietary essential fatty acids, choline, biotin, pantothenic acid, aureomycin. The vitamin occurs largely as pyridoxal in animal products and as pyridoxamine in plant products.

Functions[25]	Signs of Deficiency	Signs of Excess[26]
(A)	(B)	(C)
Growth factor (Man, monkey, rat, chicken, duck, turkey). Functions biochemically, in the form of pyridoxal phosphate, as coenzyme for transaminase and codecarboxylase systems, kynurinase, cystathionase, serine and threonine dehydrase, cysteine desulfhydrase, and racemizing enzymes; in deamination of amino acids and the formation of urea nitrogen; in conversion of tryptophan to niacin; in metabolism of (cont'd next page)	General: Retarded growth (Man: infant, monkey, rat, chick); appetite and weight loss, reduced egg production, death (Chicken). Cardio-vascular: Hypochromic anemia (Man: infant); polymorphonuclear leukocytosis, lymphopenia (Man); hypochromic, microcytic anemia with anisocytosis and irregular reticulocytosis (Dog, swine, monkey, duck, chicken); poikilocytosis (Cattle); dilatation, hypertrophy of right auricle and ventricle; increased plasma urea and NPN; tachycardia and cardiac embarrassment (Rat); mucus accumulation in thorax (Dog); impaired antibody production (Rat). Neural: Degeneration in myelin sheaths of peripheral nerves and spinal cord (Dog, swine); convulsions, epileptiform fits (Rat, swine, chicken); ataxia (Swine); convulsions (Man: infant); weakness, nervousness, irritability, insomnia (Man)[27]. Epithelium: Seborrhea-like lesions about eyes, nose, mouth; cheilosis, glossitis, stomatitis (Man[27]); denudation of hair from paws, snout, eartips, (cont'd next page)	Convulsions 24 hr after LD_{50} dose (Rat). Daily feeding of 10 mg/kg body weight for 3 months had no effect (Monkey, dog, rat).

/22/ Possibly required for prevention of "burning feet" syndrome (Man). /23/ LD_{50} mouse: orally, 10 g; subcutaneously 2.7 g; intraperitoneally 0.9 g . LD_{50} rat: subcutaneously 3.4 g/kg body weight. /24/ In animals the three forms (pyridoxine, -al, -amine) are equally active when given by injection, but pyridoxine is the most active when administered orally. /25/ In addition to its use in the treatment or prevention of pyridoxine-deficiency symptoms, the following therapeutic uses of the vitamin have been noted: treatment of muscular dystrophies associated with pellagra (Man); hyperemesis gravidarum (nausea of pregnancy); seborrheic dermatitis sicca (Man). /26/ LD_{50} rat: subcutaneously 3 g/kg body weight; orally 4 g/kg. /27/ Eight volunteers: deficiency signs produced by ingestion of desoxypyridoxine.

89. THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Continued) p162

PYRIDOXINE (VITAMIN B_6) GROUP (Concluded)

Functions	Signs of Deficiency	Signs of Excess
(A)	(B)	(C)
fatty acids. Seems to be necessary for normal adrenal-cortical function.	thickening of ears (Rat); dermatitis, bald patches (Monkey). Urine: Increased urea, ammonia, uric acid, creatinine (Dog); tryptophan metabolites in urine (Dog, hamster, mouse, rat); large amounts of xanthurenic acid (Man). Other: Anorexia, unthriftiness (Cattle); loss of weight, appetite, decreased egg production, death (Chicken).	

RIBOFLAVINE
(Vitamin B_2, or G; lactoflavin, ovoflavin, hepatoflavin)

Required by most or all vertebrates studied.

Functions	Signs of Deficiency[1,28]	Signs of Excess
(A)	(B)	(C)
As riboflavine-5-phosphate a component of a number of flavoprotein enzymes, e.g., "Warburg's yellow enzyme," cytochrome-c-reductase, riboflavine-adenine-nucleotide. As prosthetic group for various proteins functioning as enzyme hydrogen carriers, e.g., D-amino acid oxidase, xanthine oxidase, succinic dehydrogenase. Role in the visual mechanism of the retina (q.v.). Acts closely with thiamine and niacin which, like it, are components of important enzyme systems (q.v.).	General: Cessation or retardation of growth (Rat, others). Epithelium: Epidermal atrophy, dermatitis, greasy scaling especially of naso-labial folds, cheeks, chin (Man); cheilosis, angular stomatitis, lesions of lip and mouth corners (Man). Neural: Myelin degeneration of nerves (Dog, mouse, rat, swine, chicken); central neuritis (Man); lack of coordination, faulty grasp reflex (Monkey); curled toe paralysis (Chicken); partial paralysis of legs (Rat). Muscular: Muscle weakness (Dog, monkey). Gastrointestinal: Diarrhea, vomiting (Dog). Eye: Mild photophobia, dimness of vision and decline of visual acuity; itching and burning sensations of the eyes; soreness of eyes and lids (Man); cornea--cloudiness, vascularization, cataract, opacity, ulceration (Man, dog, rat). Embryological: Congenital skeletal malformations in offspring of riboflavine-deficient females (Rat). Intermediate metabolism: Profound disturbance of energy transfer and release.	5,000 times the therapeutic dose is tolerated (Rat, mouse). Kidney: Toxic amounts intraperitoneally cause anuria, renal concretions (Rat). Neural: Paresthesia, itching (Man). Other: Nausea.

THIAMINE
(Vitamin B_1; anti-neuritic factor; aneurin)

Required by most or all vertebrates studied, except ruminants whose need is satisfied by ruminal synthesis.

Functions	Signs of Deficiency[1,29]	Signs of Excess
(A)	(B)	(C)
Essential for normal growth, development and maintenance of health Essential for normal appetite, digestion, gastrointestinal tonus. Essential in the normal activity of nerve tissue. Essential in carbohydrate metabolism. As the pyrophospbate ester, (cont'd next page)	General: Retardation of growth; anorexia (Man, others). Neural: Degeneration of neurons, particularly of the vestibular group (Man, others). No peripheral nerve degeneration (Mammals). Polyneuropathies: Convulsions, hyperesthesia, anesthesia (Man, others); opisthotonos (backward retraction of head--pigeon, chicken, turkey); neurasthenia of nutritional origin (Man). Cardiac: Dilatation of the heart, myocardial lesions (Dog, fox, rat, swine); bradycardia (Monkey, cat, dog, rat, swine). Vascular: Edema (Dog, fox, rat, swine). (cont'd next page)	Vascular: Hypotension (Man, dog, rabbit).

/1/ Deficiency signs, when not irreversible, may be alleviated and the animal restored to health by administration of therapeutic doses of the vitamin. /28/ Requirement is increased in pregnancy and lactation. /29/ For man, the diverse symptoms are grouped under the syndrome of beri-beri, sometimes subdivided into "cardiac" beri-beri, "wet" beri-beri, "dry" (neuritic, paraplegic) beri-beri. Requirement for thiamine is increased by thryoxin and insulin.

89. THE VITAMINS, THEIR FUNCTIONS, SIGNS OF DEFICIENCY AND EXCESS: MAN AND OTHER VERTEBRATES (Concluded)

THIAMINE (Concluded)

Functions	Signs of Deficiency[1]	Signs of Excess
(A)	(B)	(C)
thiamine is cocarboxylase and as such participates in the decarboxylations, oxidations, dismutations, and condensations which in metabolism lead to CO_2 formation.	Gastrointestinal: Atony, spastic colon, dysphagia (Man). Intermediate metabolism: Accumulation of pyruvic acid in blood and tissues. Decrease in urinary citric acid excretion (Rat).	

ESSENTIAL UNSATURATED FATTY ACIDS
(Arachidonic acid, linoleic acid, linolenic acid)

Required by rat; probably others. Ordinarily not regarded as a vitamin.

Functions[30]	Signs of Deficiency	Signs of Excess
(A)	(B)	(C)
Arachidonic, linoleic and linolenic acids are essential to growth and reproduction (Rat). Serve as building units of the phospholipids. Catalyze the oxidation of saturated fatty acids in vitro. Exercise a protective action in pyridoxine deficiency (Rat).	General: Retardation or cessation of growth (Rat); elevated metabolic rate with diminished growth rate (Rat). Skin: Scaling of epidermis on feet and tail (Rat); eczema (Man). Hair: Alopecia (Rat). Reproduction: Delay of sexual development, disturbances of ovulation; resorption of the fetus; difficult parturition (Rat); sterility (Rat, mouse, dog); loss of sex interest (Rat). Kidney: Lesions of the kidney and urinary tract (Rat). Blood: Low iodine number in serum fatty acids. Other: Increased water intake (Rat).	Changes from normal in composition of stored fat.

/30/ The following therapeutic uses of the compounds have been noted: Cures the characteristic skin lesions associated with unsaturated fatty acid deficiency; used in treatment of certain eczematous skin conditions (Man).

90. NUTRIENT DEFICIENCY EFFECTS ON REPRODUCTION: MAMMALS

Majority of studies based on findings in the rat.

	Effect / Deficiency State	Male				Female											
						Non-pregnant or Virgin				Pregnant Mother and Fetus							
						Estrous or Menstrual Cycle											
		Prostate and Seminal Vesicle, Atrophy	Testis, Atrophy or Impairment	Germinal or Tubular Epithelium Degeneration	Spermatogensis, Impairment	Irregular	Cessation	Ovary and Uterus, Atrophy	Keratinizing Metaphasia, Reproductive Epithelium	Implantation, Impairment	Gestation and Parturition, Prolonged	Delivery of Puny Young	Congenital Abnormalities, Young	Stillborn or Non-viable Young	Fetal Death	Fetal Resorption or Abortion	Lactation Impaired
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
1	Inanition[1,2]	+	+		+	+	+	+		+		+		+	+	+	
2	Protein[2,3]	+					+	+		+		+		+	+	+[4]	+
3	"Essential" fatty acids[2,5]	+		+		+					+			+			+
4	Vitamin A	+		+	+				+	+	+	+	+	+	+	+	
5	Biotin	+	+		+		+	+							+	+	+
6	Cobalamin[6]	+	+				+	+						+	+	+	+
7	Vitamin E[3]		+	+	+								+		+[7]	+	
8	Folic acid group[3,8]												+	+	+	+	+
9	Vitamin K													+	+	+	
10	Pantothenic acid[2,3]	+	+		+		+	+		+			+		+	+	
11	Pyridoxine group[3,9]	+	+		+		+	+		+					+	+[4]	+
12	Riboflavine	+	+			+	+	+					+			+	
13	Thiamine[2]	+	+				+	+				+		+		+[4]	+
14	Calcium						+							+			+
15	Copper												+				
16	Iodine												+[10]	+			
17	Manganese		+		+	+	+			+		+		+			
18	Phosphorus					+	+					+		+			
19	Potassium				+	+				+							
20	Sodium				+	+				+							
21	Arginine[11]		+		+												
22	Histidine		+[12]														
23	Phenylalanine	+[13]	+														
24	Tryptophan		+	+											+	+	

/1/ Defined differently by every investigator. Both qualitative (dietary essentials) and quantitative (calories) deficiencies are present in the majority of studies. /2/ Deficiency probably acts via diminished secretion of pituitary gonadotropins and the resultant hypofunction of the gonads. The capacity of the gonads and the accessory reproductive organs to respond to hormonal stimuli is apparently unimpaired. /3/ Effects of a deficiency in this nutrient are observed even when the total caloric intake is maintained unchanged. /4/ Pregnancy can be maintained by estrone and progesterone. /5/ Linoleic, linolenic, arachidonic acids. /6/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /7/ Effect attributed to failure of fetal mesodermal derivatives especially those concerned with hematopoiesis, and to abnormalities of the vascular system. /8/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor. /9/ Includes pyridoxine, pyridoxal, pyridoxamine. /10/ Thyroid insufficiency? /11/ Arginine major structural component of nucleoproteins of sperm head. /12/ Also true for leucine. /13/ Also true for methionine and threonine.

91. FUNCTIONS OF ESSENTIAL ELEMENTS: HIGHER PLANTS

Element	Occurrence in Plant[1]	Functions
(A)	(B)	(C)
Boron	Cytoplasmic membranes?	Inverse relationship between boron level and water permeability of membranes and moisture content of tissues. The element is necessary for: (a) Cell division and differentiation. (b) Translocation of sucrose and possibly other sugars.
Calcium	Calcium pectate Salts of organic acids	Calcium pectate may be a constituent of the middle lamella.[2] Calcium precipitates organic acids.
Carbon	All organic compounds[3] Bicarbonate ion	Carbon is the key element in all organic molecular structures. The ion is involved in anion absorption or exchange.
Copper	Tyrosinase Ascorbic acid oxidase Laccase[4]	Tyrosinase is a polyphenoloxidase involved in reduction of molecular oxygen (terminal step in aerobic respiration). The oxidase may be concerned in respiratory oxidation.
Hydrogen	All organic compounds occurring in plants[3] Bicarbonate ion	The element is a component of these compounds. The ion is involved in anion absorption or exchange.
Iron	Peroxidase Cytochrome oxidase Catalase	Peroxidase breaks down peroxides and transfers active oxygen to oxidizable substances. The oxidase plays a role in reduction of molecular oxygen. Catalase effects the release of molecular oxygen from hydrogen peroxide.
Magnesium	Chlorophyll Co-carboxylase Enolase Hexokinase Magnesium pectate	Chlorophyll is essential for photosynthesis. Co-carboxylase is the co-enzyme for the function of carboxylases. Enolase is necessary in glycolysis (from 2-phosphoglyceric acid to 2-phosphopyruvic acid). Hexokinase brings about transphosphorylation of glucose.[5] Magnesium pectate may be a constituent of the middle lamella.[2]
Manganese	Arginase? Unidentified enzyme Unidentified enzyme	Arginase converts arginine to urea. The enzyme brings about catabolism of oxaloacetic acid into pyruvic acid and carbon dioxide in respiration. The enzyme is apparently required in ascorbic acid synthesis.
Molybdenum	Unidentified enzyme?	The element appears to effect the reduction of nitrate to ammonia.[5]
Nitrogen	Proteins Chlorophyll Many organic compounds	The element is a component of proteins, the chief organic constituents of protoplasm. Chlorophyll is essential for photosynthesis. The element is important in the assimilation of sugars.
Oxygen	Most organic compounds[3] Bicarbonate ion	The element is a component of these compounds. The element is the final receptor of hydrogen in aerobic respiration. The ion is involved in anion absorption or exchange.

/1/ The element occurs in, or in association with, the compound or structure listed. The list is not exhaustive. /2/ The middle lamella is an intercellular layer flanked on each side by the primary cell walls. /3/ These compounds include carbohydrates, fats, proteins, vitamins, hormones, and chlorophyll. /4/ The enzyme is of limited distribution, and its function is unknown. /5/ Nature of relationship undetermined.

91. FUNCTIONS OF ESSENTIAL ELEMENTS: HIGHER PLANTS (Concluded)

Element	Occurrence in Plant[1]	Functions
(A)	(B)	(C)
Phosphorus	Phospholipids[6] Nucleoprotein Adenosine di- and triphosphates Di- and triphosphopyridine nucleotide	Phospholipids are a constituent of cytoplasmic membranes. Nucleoprotein is a constituent of the nucleus and the chromosomes. These coenzymes are required for phosphorylation reactions, glycolysis and synthesis of sucrose, starch, and proteins. These coenzymes accept and/or donate hydrogen in oxidation-reduction reactions.
Potassium		The element may be involved in action of fructokinase and other enzyme systems. The element facilitates carbohydrate synthesis and translocation of carbohydrates.
Sulfur	Cystine and cysteine Glutathione Mustard oil glycosides	These compounds are present in all plant proteins. Glutathione may function as a hydrogen carrier in respiration. Glycosides may tie up reserve food substances which would otherwise be toxic to cells.
Zinc	Unidentified enzyme	The enzyme is directly necessary for synthesis of tryptophan, the precursor of indoleacetic acid.

/1/ The element occurs in, or in association with, the compound or structure listed. The list is not exhaustive. /6/ For example, lecithin.

92. SIGNS OF CHEMICAL ELEMENT DEFICIENCY AND EXCESS: HIGHER PLANTS

	Nutrient (A)	Deficiency Symptoms (B)	Toxicity Symptoms (C)
1	Boron	Terminal leaves chlorotic, shed prematurely; internodes of terminal shoots shortened, usually rosetting; apical meristems blacken and die, general breakdown of meristemstic tissue; root branches short, stubby. Plant dwarfed and stunted. Flower development and seed production usually impaired.	Marginal necrosis in lower leaves, remainder of leaves dark green; death of most plants if present in considerable concentration.
2	Calcium	Leaves chlorotic, rolled and curled; breakdown of meristemstic tissues in stems and roots, in acute cases death; roots poorly developed, lack fiber, may appear gelatinous. Symptoms appear near growing points of stems and roots. Little or no fruiting.	Chlorosis similar to iron or manganese deficiency.[1] Zinc and boron deficiency may be induced when soil reaction, e. g. pH, is altered.
3	Copper	Wilting of terminal shoots, often followed by death; leaf color often faded; carotene formation and pigmentation reduced.	Chlorosis similar to iron deficiency; followed by necrosis, permanent wilting of upper leaves; leaves may become wrinkled and necrotic at margins; fibrous roots stubby, poorly developed; brownish at tips; reduced growth; extreme cases death.
4	Iron	Interveinal white chlorosis, appearing first on young leaves, tendency for chlorosis of all aerial parts, often becoming necrotic; in some cases leaves may be completely bleached, margins and tips scorched. Usually has an overall effect.	Same as phosphorus or manganese deficiency.
5	Magnesium	Mottled chlorosis with veins green and leaf web tissue yellow or white, appearing first on old leaves; severely affected leaves may wilt and shed, or may abscise without the wilting stage; brittleness of leaves common, necrosis often occurs.	Same as calcium deficiency.
6	Manganese	Mottled chlorosis with veins green and leaf web tissue yellow or white, appearing first on young leaves, may spread to old leaves; stems yellowish green, often hard and woody. Carotene development reduced.	Leaves pale, necrotic, bronzing at margins; similar to iron deficiency. With potato, small black spots on stem.
7	Molybdenum	Leaves have light yellow chlorosis; leaf blade may fail to expand.	Lower leaves yellow with brown necrotic areas; in severe cases, upper leaves may be stunted, chlorotic and abscise.
8	Nitrogen	In young plants stunted growth and yellowish green leaves; older leaves light green, followed by yellowing and drying or shedding, often abundant anthocyanins in veins; shoots short, thin, growth upright and spindly; blossoming reduced; with apple and peach, fruit highly colored, develops slowly, small when mature. Usually has an overall effect.	Leaves dark green, excessive vegetative growth; high transpiration; reduced yield of seed and fruit crops may secure satisfactory yield of leafy vegetables but reduced quality (lack succulence).
9	Phosphorus	Leaves pale green[2], often anthocyanins (usually purple) in veins, may become necrotic; with potato, meristemstic growth ceases; fruits ripen slowly; plants often dwarfed at maturity.	Same as iron deficiency. May induce zinc deficiency.
10	Potassium	Leaves usually dark blue green (sometimes bronzed) with marginal chlorosis and necrosis, appearing first on old leaves; usually wrinkled, corrugated or crinkled between veins.	Leaves yellowish green; reduced growth; tendency toward calcium and magnesium deficiency.
11	Sulfur	Leaves light green to yellow, appearing first along veins of young leaves; stems often slender.	No evidence except as acidity of root medium is influenced.
12	Zinc	Leaves chlorotic and necrotic, appearing first on young growth, rosetting, premature shedding, whitish chlorotic streaks between veins in older leaves and whitening of upper leaves in monocotyledons, chlorosis of lower leaves in dicotyledons.[3]	Leaves yellow from zinc induced iron chlorosis.

/1/ Chlorosis due to the physiological unavailability of iron and manganese or reduced potassium. /2/ With potato and certain other vegetables, leaves dark green. /3/ Young plants showing deficiency symptoms often lose symptoms when roots penetrate the subsoil.

93. SIGNS OF CHEMICAL ELEMENT DEFICIENCY: EIGHT SELECTED PLANTS (Section I)

	Species / Element	Alfalfa (Medicago sativa)	Apple (Pyrus malus)	Cabbage (Brassica oleracea capitata)	Citrus (Citrus spp.)
	(A)	(B)	(C)	(D)	(E)
1	Boron	Terminal leaves yellow to red, followed by death of terminal buds; internodes of terminal shoots shortened forming a rosette; in severe cases blossoms fail to develop.	Terminal growth of shoots die back in early spring or late summer, internodes shortened; leaves dwarfed, chlorotic, thickened, brittle, with margins commonly unserrated; fruit may show external cork spots and internal necrosis around vascular bundles; bark with lesions.	Plants dwarfed; leaves puckered along midrib, brittle, stiff, thick, mottled along margins; petioles with swellings, becoming corky; water-soaked appearance of pith area in stem of head region.	Terminal shoots die back; leaves brownish yellow, with water soaked spots, vein chlorosis and necrosis, shed prematurely; fruit may be small, misshapen, with small brown areas in rind.
2	Calcium		Young leaves necrotic at tip, margin or along midrib, tips and margin curving, old leaves have necrotic areas; roots short, bulbous, dying back from tips after making short growth.	Plants dwarfed, growing point dies; young leaves chlorotic, rolled, ragged, becoming necrotic; older leaves dull green.	Shoots die back from tip; leaves have interveinal and marginal chlorosis and necrosis; shed prematurely; roots may decay.
3	Copper	Terminal leaf petioles have epinastic curvature, leaflets fold backward along petioles, followed by wilting and death.	Terminal leaves brown spotted, followed by necrosis, wilt; shoot tips wither and die back; bushy growth.	Leaves chlorotic; heads fail to form; growth stunted.	Leaves large, dark green, twisted and bowed, on long, soft, angular shoots; in acute cases multiple buds on heavy twigs, developing soft shoots die back from tips with reddish excrescence over bark; fruits may be bumpy and covered with reddish brown excrescences, gum pockets internally, often split and shed; roots may show gumming.
4	Iron	Terminal leaves chlorotic, lower leaves remain green; in severe cases entire foliage chlorotic; terminal internodes shortened; flowers fail to form.	Terminal leaves chlorotic, spreading downward on twigs; shoots die back when severely affected; fruit highly colored.	Terminal leaves chlorotic.	Terminal leaves chlorotic between veins; leaves thin, in acute cases yellow to orange and necrotic, shedding prematurely; fruit sparse, small, hard, coarse, light in color.
5	Magnesium	Older leaves become orange-yellow, often with red tints.	Older leaves of terminal growth light green to brown, blotches between veins, often extending to margins shed prematurely; fruit may fall to ripen on tree.	Older leaves have interveinal chlorosis, brittle, puckered; severe chlorosis may be followed by yellowing around margins and at center.	Older leaves chlorotic with a wedge of green along midrib, followed by chlorosis of entire leaf, shed prematurely; shoots die back.
6	Manganese	Leaves have interveinal chlorosis; root and top growth greatly retarded.	Leaves have interveinal chlorosis.	Leaves have bronze-yellow interveinal mottling, chlorotic between veins, small; young leaves affected first.	Leaves have dull yellow-green interveinal chlorosis; fruit pale in color when ripe.

7	Molybdenum	Leaf chlorosis similar to that of nitrogen deficiency; growth reduced.		Leaves have marginal and interveinal yellow-green mottling; old leaves leathery, curled, withered, especially at tip and margin; in severe cases shrivel and abscis.	Leaves have numerous random, irregular, chlorotic spots, usually 4-12 mm in diameter, yellow on upper surface, brownish on lower surface; shed prematurely.
8	Nitrogen	Leaves yellow; older leaves affected first; roots long and fibrous.	Leaves small, pale green; older leaves pigmented orange, red or purple, shed prematurely; petioles at narrow angles with shoots; fruits small and highly colored when ripe.	Young leaves pale green; older leaves dull purple, margins die; heads small, firm.	Leaves yellowish green to yellow, shed prematurely, terminal growth short, sparse; shoots die back.
9	Phosphorus	Leaves bluish-green, blades may tilt upward; stems usually become reddish-purple; plant spindly, growth rate retarded; poor tillering.	Leaves small, dark green with purple pigmentation; older leaves mottled with yellow, dark green areas, shed prematurely; petioles at narrow angle with shoots; shoots slender, purpliah; (not cold hardy); fruit bud formation reduced; fruit small, variable in color.	Leaves dull purple, shed; heads small, firm.	Older leaves dull bronze green, often with blackened necrotic areas, shed prematurely; shoots die back; fruit large, coarse, acid, may drop prematurely.
10	Potassium	Leaflets chlorotic as small dots around leaf margins in initial stages, later enlarging, necrotic, margins brown, ragged. Older leaves more affected than young leaves.	Leaves bluish green, followed by interveinal chlorosis to marginal necrosis; do not shed readily; shoot growth short; fruit small, poorly colored.	Leaves yellow; severe tipburn of outer leaves; heads usually hard.	Leaves small, crinkled or curled with marginal scorching; fruit small, high in sugar, low in acid.
11	Sulfur	Similar to nitrogen deficiency; young leaves affected first.	Leaves pale green.	Leavea pale yellowish green	Leaves yellow, especially younger leaves; shoots die back; immature fruit light green; ripe fruit light orange, pulpy, sometimes dwarfed, misshapened, peel thick.
12	Zinc	Leaf margins roll inward, chlorotic areas appear along leaf margins or between veins; roots turn brown, thicken, become stunted and clubby.	Spring growth characterized by whorls or rosettes of small, stiff, mottled leaves; fruit bud formation reduced; fruits small, malformed; shoots may die back.		Leaves have interveinal chlorosis, mottled appearance, small, slender; shoots die back; some fruit small, misshapen.

93. SIGNS OF CHEMICAL ELEMENT DEFICIENCY: EIGHT SELECTED PLANTS (Section II)

	Species / Element	Corn (Zea mays)	Lettuce (Lactuca sativa)	Tobacco (Nicotiana tabacum)	Tomato (Lycopersicon esculentum)
	(A)	(F)	(G)	(H)	(I)
1	Boron	Newly formed leaves have elongated watery stripes, becoming white on drying, growing point necrotic; older leaves have yellowish-white stripes; sterility common, developed ears may show corky brown bands at base of kernels.	Terminal leaves puckered, curled, with necrosis at margins, followed by death of growing point.	Terminal bud leaves light green, twisted, necrotic at basal portion, followed by death of terminal buds; upper leaves light green, curled, stiff, brittle, vascular tissue with dark discolorations; flowers shed; roots poor, have many branches.	Stem apex becomes yellow, then brown, followed by death; terminal leaves small, twisted, chlorotic, necrotic; older leaves stiff, brittle, become purple; vascular tissue breaks down; roots poorly developed, yellow to brown; fruits frequently have darkened or dried areas.
2	Calcium	Leaf tips of innermost unfolding leaves gelatinized and adhere upon drying.	Young leaves chlorotic, wrinkled by restricted growth, rosette condition may develop.	Leaves of terminal buds and lateral branches light green, hook downward, necrotic at tips and margins, often followed by death of terminal buds; flowers show breaking down of corolla and shed; roots short, much branched.	Young leaves of terminal growth yellowish brown or purple, becoming necrotic; leaf edges curl downward; terminal flowers die; plants weak, lose turgor; roots short, much branched, stubby, brown.
3	Copper	Plants stunted; leaves pale yellow or reddish yellow.	Leaves chlorotic, curled; growth stunted; heads soft.	Terminal leaves lose turgor, followed by permanent wilting, gray-green necrosis on older leaves; seed stalk drooping.	Terminal shoots stunted; leaves dark bluish green, curled inward, soft, chlorotic; petioles and stems small, soft; flower formation absent.
4	Iron	Young leaves have pale striping becoming more pronounced with alternating dark green and yellow to white stripes, extending entire length of leaves; young leaves may be almost white, middle leaves with stripes and older leaves with healthy characteristic color.		Young leaves have interveinal chlorosis, becoming yellowish white including veins; older leaves have healthy characteristic color; roots little branched.	See tobacco.
5	Magnesium	Older or lower leaves have interveinal and marginal chlorosis producing a streaked effect, followed by necrosis of chlorotic areas.	Older leaves have chlorotic mottling.	Older leaves progressively chlorotic, occurring with less of green in lower leaves at tips, margins and interveins; roots long, little branched, slimy; stalks slender.	Older leaves have interveinal chlorosis and necrosis, petioles hang downward; stalks slender; roots long with few branches. Brown dead areas appear along the edges of the leaflets in severely affected plants.
6	Manganese	Leaves have chlorotic streaks, more or less continuous from base to tip, made up of a chain of chlorotic spots with irregular margins. Occurs first on young leaves.	Leaves chlorotic, becoming necrotic.	Young leaves chlorotic with branches of veins green, interveins light green to white, with reticulated appearance, followed by necrosis as small spots over entire leaf.	See tobacco.

7	Molybdenum		Young leaves chlorotic, mottled, curled; older leaves have web chlorotic margins, veins light green, leaf margins shrivel and die.	See tomato.	Lower leaves have chlorotic mottling and necrosis, margins curl.
8	Nitrogen	Young plants stunted, leaves yellowish-green; in older plants lower leaves show yellowing and dying at tips and progressing along midveins with margins remaining green, finally the entire leaf dies. First symptom is a general paling of foliage.	Leaves pale green; older leaves show yellowing followed by death and drying or firing; heads small and firm.	Leaves erect, small, light green; older leaves lemon to orange-yellow, followed by drying to light brown; stalks slender; roots long and little branched.	Leaves light green; lower leaves yellow, followed by drying, veins deep purple; flower buds yellow, shed; fruit small, firm, highly colored when ripe.
9	Phosphorus	Young plants stunted, leaves dark green or purplish; stalks slender; maturity delayed which may result in poor pollination and irregular rows of kernels on ear.	Leaves dull green, older leaves yellow; small firm heads; growth stunted.	Leaves dark green, narrow, erect; older leaves may become necrotic, turning dark brown to black; maturity delayed.	Leaves dark green, purple pigmentation on underside; older leaves turn black upon drying.
10	Potassium	Leaves yellow to yellow-green streaked, corrugated, followed by necrosis of margins and tips, more pronounced on older leaves; narrow angle between base of leaf blade; internodes short; tip end of ears poorly filled.	Leaves dark green; older leaves have marginal, interveinal necrosis.	Leaves bluish green with brown to rusty necrotic areas, cupped at tips and margins; stalks slender; roots long with few branches, slimy.	Lower leaves yellowish or grayish green along margins and tips, followed by brown necrosis; stalks slender; fruit soft, uneven ripening.
11	Sulfur	General paling of foliage over all of plant; similar to nitrogen deficiency.		Younger leaves lighter green than older leaves, followed by all leaves becoming light green, sometimes with necrosis and blistering; roots abundant, much branched.	Leaves pale green, undersides of veins purple; stems slender, stiff, woody; roots abundant, much branched, small in diameter.
12	Zinc	Older leaves have whitish chlorotic streaks between veins, becoming necrotic; in acute cases plants stunted throughout season and produce no ears; in some cases young leaves in bud white to light yellow. Young plants show symptoms before older plants.		Lower leaves thick, slight chlorosis at tips and margins, becoming necrotic; internodes shortened.	Leaflets small, mottled, necrotic, with midribs shortened.

94. CORRELATION BETWEEN SOIL pH AND SIGNS OF CHEMICAL ELEMENT DEFICIENCY

Data represent soil type and pH ranges in which deficiencies of various elements most commonly occur.

Element	Factors Promoting Deficiencies			Organisms Serving as Deficiency Indicators[2]
	Soil pH		Soil Type and Other Characteristics	
	Range	Significance[1]		
(A)	(B)	(C)	(D)	(E)
Aluminum[3]	5.5-8.0	High		Hydrangea
Boron	5.0-8.0	Medium to low	Calcareous soils with high calcium-boron ratio, frequently on leached acid sandy soils low in organic matter, particularly under intensive cropping.	Apple; beet; cauliflower, kale, turnip; celery, legumes; tobacco.
Calcium	<4.5[4,5]	High	Light sandy soils; highly acid soils	Alfalfa, beet, celery, clovers, flax, peas, potato, tomato.
Cobalt			Availability decreases with increasing pH.	Ruminants and other animals feeding on Co-deficient plants.
Copper	<5.0;7.6-8.5	Medium	Heath soils and peat; acid and calcareous sands and gravels.	Cereals; apple; pear; citrus; peach, plum, etc.; flax; various grasses; legumes; lettuce; onion; tomato.
Iodine		Low	Areas of calcareous rocks, river flats and alluvial soils.	Animals feeding on I-deficient plants.
Iron	>7.0[6]	Medium to high	Particularly on calcareous soils; may be induced on acid soils by high concentration of heavy metals.	Apple; sugar beet; pear; citrus; peach, plum etc.; grape; pineapple; raspberry; strawberry.
Magnesium	<5.0	Low	Light acid sandy soils; may be induced by heavy application of potassium and calcium fertilizers.	Apple, sugar beet, cauliflower, citrus, kale, lettuce, oats, potato, tobacco, tomato.
Manganese	6.5-8.0	High	Soils high in organic matter, calcareous soils.	Bean, beet, grasses, oats, potato, tomato, tree and bush fruits (except citrus).
Molybdenum	4.5-6.5	High	Light, leached, acid soils.	Sugar beet; cauliflower, swede, kale, Brussels sprouts, etc.; citrus; legumes; lettuce; tomato.
Nitrogen	<5.5	Low	Particularly light acid soils; of general occurrence.	Non-legumes. Legumes at low pH (induced by Mo-deficiency).
Phosphorus	<6.0;7.0-8.0	Medium to high	Particularly acid soils; clay and certain calcareous soils.	Beet, cereals, other grasses, legumes, cotton, potato, swede, turnip
Potassium	<5.5	Medium	Sandy soils, particularly when leached; light calcareous soils.	Beet, corn, tree and bush fruits, legumes, potato, tobacco, tomato, tung tree.
Sodium	<5.5	High	Sandy, inland soils.	Beet, carrot, celery, swede, turnip.[7]
Sulfur	<5.0	Low	Particularly on leached, eroded soils of areas remote from urban and industrial districts	Cotton, flax, legumes, tea.
Zinc	<4.5;7.6-8.2	Medium to low	Soils with high organic matter; leached sands and gravels.	Sugar beet, cacao, cereals, citrus and other tree fruits, clover, flax, various grasses, potato, swede, tomato, tung tree.

/1/ Classified as: high = symptoms seldom occur outside the stated pH; medium = symptoms occur most commonly within the stated pH; low = symptoms occur at all pH values. /2/ Species most sensitive to a deficiency state, and therefore exhibiting symptoms of deficiency of the element in a short period of time. /3/ Data refer to the role of aluminum in producing blue pigments in hydrangea flowers. /4/ Reported to be 5.5-6.3 with flax growing on certain waterlogged soils. /5/ Reported to be 5.5 on very acid sandy soils which have been treated with magnesium limestone. /6/ Reported to be 7 for citrus crops. /7/ Sodium is utilized by certain higher plants and is considered an essential element for beets.

95. CORRELATION BETWEEN SOIL pH AND SIGNS OF CHEMICAL ELEMENT EXCESS

Data represent soil type and pH ranges in which toxicities of various elements most commonly occur.

Element	Factors Promoting Toxicities			Organisms Serving as Toxicity Indicators[2]
	Soil pH		Soil Type and Other Characteristics	
	Range	Significance[1]		
(A)	(B)	(C)	(D)	(E)
Aluminum	<5.5	High	Often accompanied by phosphorus deficiency.	Barley, sugar beet, carrot, celery, flax, leek, some var. French bean.
Arsenic		Low	From continued use of arsenical sprays.[3]	Alfalfa, apricot, barley, peach, tomato.
Boron	<5.5;>8.2		Light soil irrigated with boron-rich water.	Avocado; citrus; blackberry; peach, plum, etc.; potato.
Cobalt	<5.0		Acid soils, with high concentration of heavy metals, particularly from industrial effluent.	Sugar beet, cauliflower, tomato.
Copper	<5.0		See cobalt.	Sugar beet, cauliflower, tomato.
Fluorine	<6.5	High	Areas of industrial pollution.	Barley, buckwheat, collards, tomato.
Lithium	>8.2		Certain irrigated soils.	Citrus, corn, tomato, wheat.
Manganese	<5.5	High	General occurrence. Often in rather impervious mineral soils.	Alfalfa, barley, kale, lespedeza, potato, swede, sweetclover, tomato, vetch.
Molybdenum	7.0-7.5	High	Soils derived from rocks high in molybdenum content.	Ruminants feeding on Mo-rich plants[4].
Nickel	<6		Availability decreases with increasing soil pH.	Beet, cabbage, kale, turnip, clover, oats, potato, tomato.
Selenium			Soils derived from Upper Cretaceous rocks (in America) and Upper Carboniferous limestone (in Ireland).	Animals feeding on Se-rich plants.
Zinc	<5.0		See cobalt.	Sugar beet, cauliflower, tomato.

/1/ Classified as: high = symptoms seldom occur outside the stated pH; medium = symptoms occur most commonly within the stated pH; low = symptoms occur at all pH values. /2/ Species most sensitive to a toxicity state and therefore exhibiting symptoms of excess of the given element in a short period of time. /3/ Reported to occur in oats from the presence of minerals containing arsenic in the soil. /4/ Inconsistent results with field plants.

96. FUNCTIONS OF ESSENTIAL ELEMENTS: BACTERIA

The functions listed in the table require the specific elements noted. In addition, carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur are required for the functions of synthesis of structural proteins, carbohydrates, fats and other organic compounds, and for formation of end products of bacterial metabolism.

Bacteria	Elements	Essential Function or Role
(A)	(B)	(C)
Heterotrophic Bacteria[1]		
Aerobacter aerogenes	Fe	Needed for growth.
	Mg, Mn	In the enzyme system transforming pyruvate to acetylmethyl-carbinol.
	Cr or Mn (partially replaceable by Al, Cu, Fe, Zn)	Required for normal fermentation.
Aerobacter indologenes	Fe	In hydrogenase, formic dehydrogenase, formic hydrogenlyase, and cytochrome.
Azotobacter spp.	Fe	Needed for growth.
	Ca (replaceable by Sr)	Required for nitrogen fixation.
	Mo (partially replaceable by V)	Required for nitrogen fixation.
	Co, Mg, Mn, Zn	In oxalacetate decarboxylase.
Bacillus anthracis	Ca, Fe, K, Mg, Mn	Needed for growth.
Bacillus cereus	K	Needed for spore formation.
Bacillus subtilis	Fe, K, Mg, Mn, Zn	Needed for growth and production of subtilin (antibiotic).
Brucella abortus	Mg or Mn	Needed for normal growth of the antigenic nonsmooth variants.
Brucella suis	Fe, Mg, Mn	Needed for growth.
Cellulomonas spp	Mg	Needed for growth.
Clostridium acetobutylicum	Fe	Required for normal fermentation.
	Mn, Zn	In phosphatase.
	Mo (partially replaceable by V)	Required for nitrogen fixation.
Clostridium botulinum	Fe	In polypeptidase.
Clostridium butyricum	Mo (partially replaceable by V)	Required for nitrogen fixation.
Clostridium histolyticus	Fe	In polypeptidase.
Clostridium perfringens	Mg	Necessary for cell division.
	Fe	Needed for normal fermentation.
Corynebacterium diphtheriae	Fe	Needed for growth and formation of toxin and porphyrin.
Escherichia coli	Fe	Needed for growth.
	Mg, Mn	In pyruvic dehydrogenase.
	Mg, Mn	In enolase.
Hemophilus influenzae	Fe	Part of the growth factor hemin.

/1/ Utilize organic materials such as sugars, fatty acids, amino acids, alcohols, etc., as source of carbon for energy and growth.

96. FUNCTIONS OF ESSENTIAL ELEMENTS: BACTERIA (Continued)

The functions listed in the table require the specific elements noted. In addition, carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur are required for the functions of synthesis of structural proteins, carbohydrates, fats and other organic compounds, and for formation of end products of bacterial metabolism.

Bacteria	Elements	Essential Function or Role
(A)	(B)	(C)
Heterotrophic Bacteria[1] (concluded)		
Klebsiella pneumoniae	Fe	Needed for growth.
Lactobacillus arabinosus	Mn	Needed for growth.
	K	Needed for growth.
Lactobacillus casei	Mn	Needed for growth.
	K	Needed for growth.
Lactobacillus lactis	Co	Part of the growth factor vitamin B_{12}.
Lactobacillus leichmanii	Co	Part of the growth factor vitamin B_{12}.
Leuconostoc mesenteroides	K, Mn, P	Needed for growth.
Propinonibacterium jensenii	Mg, Zn	In phosphatase.
Pseudomonas aeruginosa	Fe, S	Needed for production of pyocyanine (antibiotic).
	Mg, P, S	Needed for production of fluorescent pigment.
	Fe	In cytochrome, cytochrome oxidase, catalase, and peroxidase.
	Mg	Needed for growth.
Pseudomonas spp	B, Ca, Co, Cu, Fe, Mn, Mo, Zn	Needed for growth.
Serratia marcesens	Fe, Mg	Needed for pigment formation.
Sporocytophaga myxococcoides	Fe, Mg	Needed for growth and decomposition of cellulose.
Streptococcus faecalis	K, Mn, P	Needed for growth.
Misc. unidentified bacteria	Ca, Mg	In protease.
	Zn	In polypeptidase.
Photosynthetic Bacteria[2]		
All photosynthetic bacteria	Mg	Part of bacteriochlorophyll.
Athiorhodaceae (nonsulfur purple bacteria)	B, Ca, Cu, Fe, Ga, Mn, Zn	Needed for growth.
Thiorhodaceae (sulfur purple bacteria)	S required in the form of sulfide, sulfite, thiosulfate.	Indispensable reducing agent for photosynthesis.
Sulfur green bacteria	S required in the form of sulfide.	Indispensable reducing agent for photosynthesis.

/1/ Utilize organic materials such as sugars, fatty acids, amino acids, alcohols, etc., as source of carbon for energy and growth. /2/ Capable of growing on CO_2 as the sole source of carbon, by utilizing light energy.

96. FUNCTIONS OF ESSENTIAL ELEMENTS: BACTERIA (Concluded)

The functions listed in the table require the specific elements noted. In addition, carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur are required for the functions of synthesis of structural proteins, carbohydrates, fats and other organic compounds, and for formation of end products of bacterial metabolism.

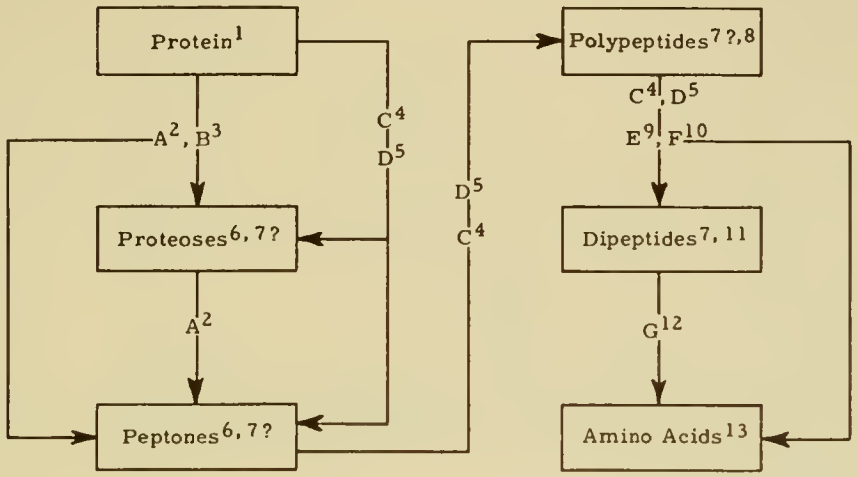
Bacteria	Elements	Essential Function or Role
(A)	(B)	(C)
Chemoautotrophic Bacteria[3]		
Hydrogenomonas species	H	Molecular hydrogen oxidized as the source of energy.
Nitrifying bacteria	Cu	Needed for nitrification (oxidation of ammonia and nitrite).
Nitrosomonas species (ammonia-oxidizing nitrifiers)	N in the form of ammonia	Indispensable as the substrate oxidized to provide energy.
Nitrobacter species (nitrite-oxidizing nitrifiers)	N in the form of nitrite	Indispensable as the substrate oxidized to provide energy.
Thiobacillus species (sulfur-oxidizers, all aerobic)	S in reduced form such as S, sulfide, thiosulfate	The substrate oxidized to provide energy.
Thiobacillus denitrificans (sulfur-oxidizer, anaerobic)	Reduced sulfur (as above)	The substrate oxidized to provide energy.
	N in the form of nitrate	Indispensable as the oxidizing agent
Sporovibrio desulfuricans (sulfate-reducer)	S in the form of sulfate	Indispensable as the oxidizing agent.
Clostridium aceticum	H	Molecular hydrogen oxidized as the source of energy.
	CO_2	Employed as oxidizing agent.
Methanobacterium omelianski	H	Molecular H oxidized as the source of energy.
	CO_2	Employed as oxidizing agent.
Iron bacteria	Fe, Mn	The substrates oxidized to provide energy.

/3/ Capable of growing with CO_2 as the sole source of carbon and with energy derived from the oxidation of inorganic materials. A few of these organisms grow only autotrophically but most of them can develop either as heterotrophs or as autotrophs.

97. CHEMICAL CHANGES IN PROTEIN DIGESTION AND ABSORPTION: MAN, LABORATORY MAMMALS

Protein digestion, in the alimentary canal, comprises the enzymatic cleavage of the protein molecule into its component amino acids which are absorbed into the blood stream. Although the diagram is a summary of present knowledge of the field, controversy still exists with regard to some of the details.

A = Pepsin; B = Rennin; C = Trypsin; D = Chymotrypsin; E = Carboxypolypeptidase; F = Aminopolypeptidase; G = Dipeptidase

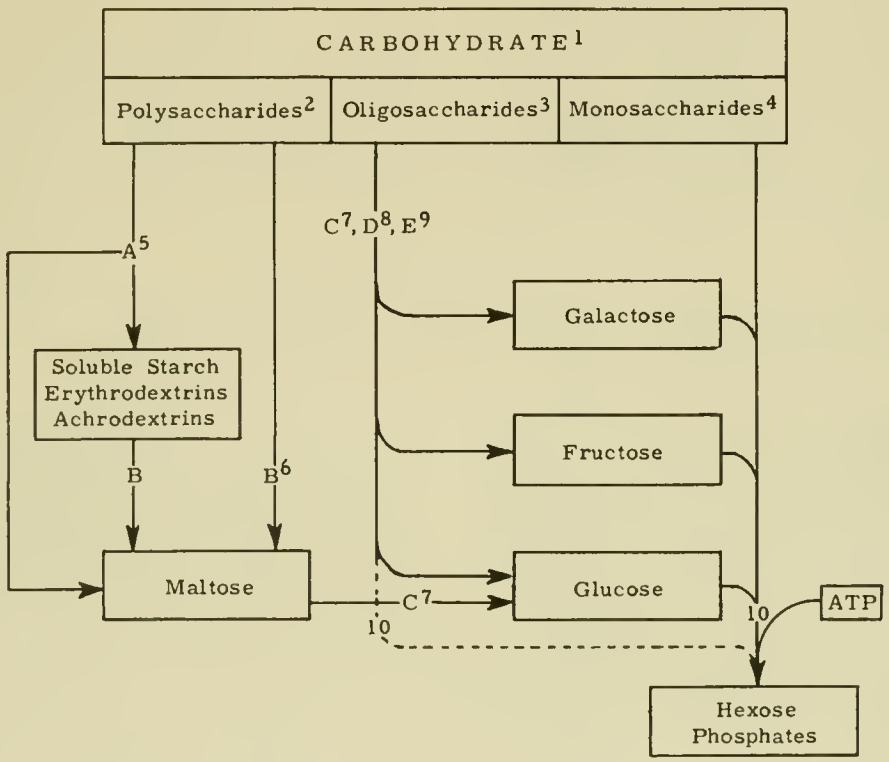


/1/ Native, denatured, or coagulated. /2/ Secreted by the gastric mucosa as pepsinogen; activated by HCl. Pepsin is an autocatalytic endopeptidase, hydrolyzing peptide bonds in the interior of the protein molecule. /3/ In gastric juice of the young of some mammals, but probably not the adults; converts soluble calcium caseinate to insoluble calcium paracaseinate (clot). /4/ Secreted in pancreatic juice as trypsinogen; activated by enterokinase. Trypsin is an autocatalytic endopeptidase, hydrolyzing native proteins to proteoses, peptones, and polypeptides by splitting peptide bonds involving a basic nitrogen (as in lysine, arginine). /5/ Secreted in pancreatic juice as chymotrypsinogen; activated by trypsin. Chymotrypsin is an endopeptidase, hydrolyzing native proteins to proteoses, peptones, and polypeptides by splitting peptide bonds involving an aromatic group (as in tyrosine, phenylalanine). /6/ Secondary protein derivatives of molecular weight less than 1000, exclusive of polypeptides and simpler degradation products. /7/ Some absorption. /8/ A compound containing more than two amino acids joined by peptide linkages. /9/ One of several exopeptidases (called erepsin) in pancreatice juice removing successively amino acids with free carboxyl groups from the end of the peptide chain, thus hydrolyzing polypeptides to simpler peptides and amino acids. /10/ Secreted by intestinal mucosa in succus entericus; an exopeptidase, removing successively amino acids with free amino groups from the end of the peptide chain, thus hydrolyzing polypeptides to simpler peptides and amino acids. /11/ Dipeptides contain two amino acids. /12/ Secreted by intestinal mucosa in succus entericus; hydrolyzes dipeptides to amino acids by breaking the peptide linkage. /13/ Absorbed.

98. CHEMICAL CHANGES IN CARBOHYDRATE DIGESTION AND ABSORPTION: MAN, LABORATORY MAMMALS

Carbohydrate digestion is the enzymatic hydrolysis of poly- and oligosaccharides into their monosaccharide components which are then absorbed into the blood stream. Monosaccharides are phosphorylated to hexose-6-PO_4? as they enter the intestinal mucosa and then dephosphorylated before they enter the blood stream.

A = Salivary amylase (ptyalin); B = Pancreatic amylase (amylopsin); C = Maltase; D = Sucrase (invertase); E = Lactase

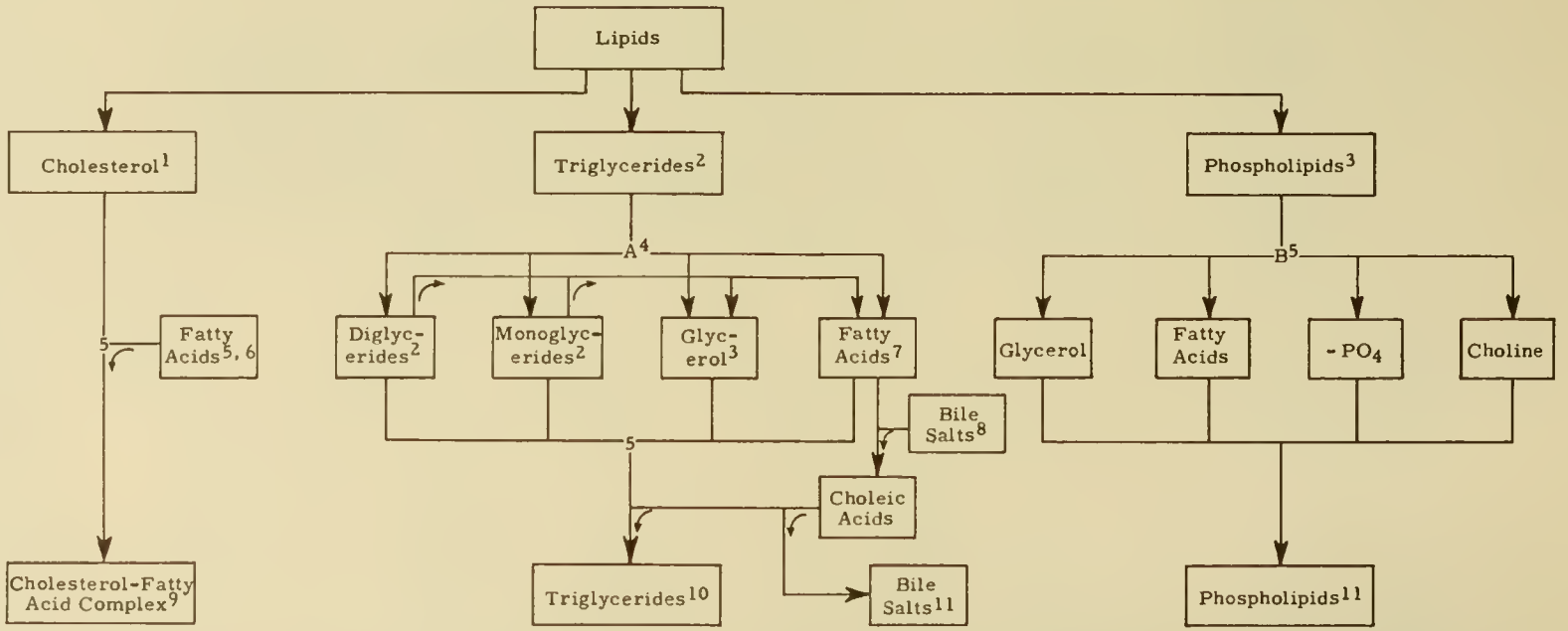


/1/ Ingested. /2/ Polysaccharides including glycogen, starch dextrins and cellulose are made up of many monosaccharide (simple sugar) molecules. Cellulose, although made up of glucose molecules is not digestible by mammals. /3/ Oligosaccharides are carbohydrates composed of only a few (down to two in the case of disaccharides) molecules of monosaccharide. Sucrose contains glucose and fructose; maltose is composed of two molecules of glucose; and lactose contains glucose and galactose as constituents. /4/ Ingested monosaccharides are absorbed into the blood stream without breakdown. /5/ Salivary amylase not only converts polysaccharides to soluble starch, etc., but also breaks off some maltose. /6/ Pancreatic amylase, but not salivary amylase, will hydrolyze uncooked starch only to an insignificant extent. /7/ Maltase, in intestinal secretion, hydrolyzes each molecule of maltose to two molecules of glucose. /8/ Sucrase, in intestinal secretion, hydrolyzes sucrose to glucose and fructose. /9/ Lactase, in intestinal secretion, hydrolyzes lactose to glucose and galactose. /10/ Possibly other hexoses.

99. CHEMICAL CHANGES IN LIPID DIGESTION AND ABSORPTION: MAN, LABORATORY MAMMALS

Details of digestion and absorption of lipids are not as well established as those for protein and carbohydrate. The pathways as presented may be expected to undergo some modification with further research in the field.

A = Pancreatic lipase (steapsin); B = Lecithinase



/1/ Absorbed in the presence of fat (except in rabbits); excess cholesterol may hinder fat absorption. Some conversion to coprosterol by intestinal bacteria and excreted as such. Plant sterols are not absorbed? /2/ Tri-, di-, and monoglycerides = compounds of glycerol and 3 or 2 or 1 molecule fatty acid. Some absorption ? /3/ Absorbed. Include (a) lecithins, (= glycerol + fatty acids + phosphoric acid + choline), (b) cephalins (+ glycerol + fatty acids + phosphoric acid + cholamine or serine, or inositol) and (c) sphingomyelins (+ fatty acid + phosphoric acid + choline + sphinogosine). /4/ In intestinal lumen. /5/ In intestinal mucosa. /6/ From hydrolysis of glycerides or phospholipids. /7/ Short-chain (i.e. 10 carbon or less) fatty acids, being water soluble, are readily absorbed into the intestinal mucosa; long chain fatty acids absorbed with the aid of bile salts (q.v.). /8/ In addition to forming choleic acid complexes with fatty acids, bile salts serve as emulsifying agent to hasten absorption of lipid digestion end products. /9/ Absorbed into lymphatic system. /10/ Mono- and diglycerides and fatty acids and glycerol (from triglyceride or phospholipid hydrolysis) recombine in the intestinal mucosa to form triglycerides of different composition from those ingested. Those containing short-chain fatty acids are absorbed chiefly into the portal blood stream; the more insoluble fats containing long-chain fatty acids are absorbed through the lacteals into the lymphatic system. /11/ Absorbed into portal blood.

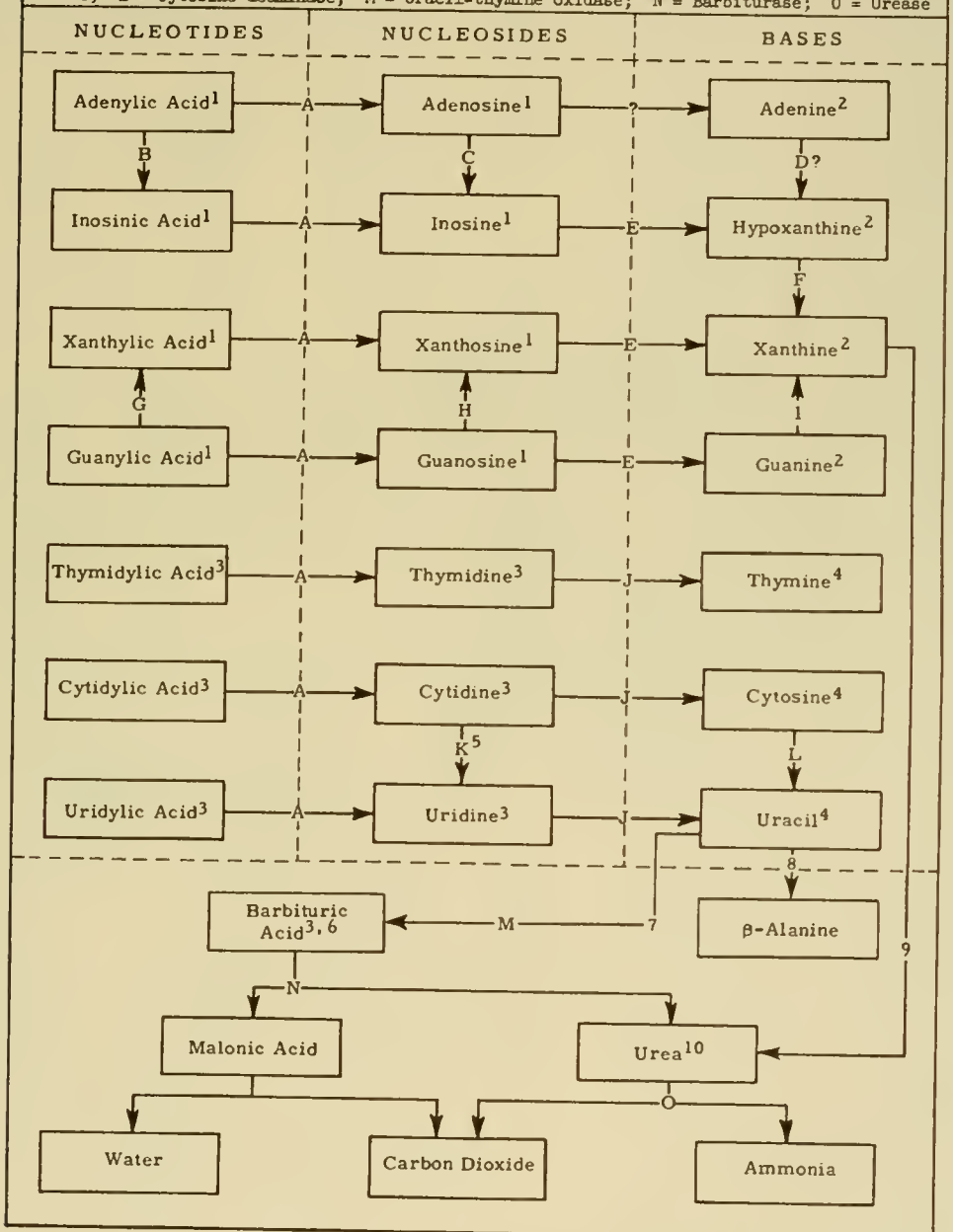
100. PATHWAYS OF AMINO ACID METABOLISM

	Amino Acid	Product of Oxidative Deamination or Transamination	Product of Decarboxylation	Pathways and Products of Metabolism
	(A)	(B)	(C)	(D)
1	L-Alanine	Pyruvic acid		
2	L-Arginine	α-Keto-δ-guanidovaleric acid	Agmatine	Arginine ⟶ ornithine + urea Arginine ⟶ citrulline + NH_3
3	L-Asparagine	α-Ketosuccinamic acid		Asparagine ⇌ aspartic acid + NH_3
4	L-Aspartic acid	Oxalacetic acid	α-Alanine, β-Alanine	Aspartic acid ⇌ fumaric acid + NH_3; other products include: malic acid, succinic acid, propionic acid
5	L-Citrulline	α-Keto-δ-carbamidovaleric acid		Citrulline + NH_3 ⟶ arginine Citrulline ⟶ ornithine + CO_2 + NH_3
6	L-Cysteine	β-Mercapto-pyruvic acid		Cysteine sulfenic acid ⟶ cysteine sulfinic acid ⟶ cysteic acid ⟶ taurine; cysteine ⟶ H_2S + NH_3 + pyruvic acid
7	L-Glutamic acid	α-Ketoglutaric acid	γ-Aminobutyric acid	See ornithine, proline, histidine, glutamine
8	L-Glutamine	α-Ketoglutaramic acid		Glutamine ⇌ glutamic acid + NH_3
9	Glycine	Glyoxylic acid		Glycine + formate ⇌ serine + NH_3
10	L-Histidine	β-Imidazolepyruvic acid	Histamine	Histidine ⟶ urocanic acid ⟶ glutamic acid
11	L-Hydroxyproline	α-Keto-γ-hydroxy-δ-aminovaleric acid		See proline
12	L-Isoleucine	D-α-Keto-β-methylvaleric acid		α-Keto-β-methylvaleric acid ⟶ α-methylbutyric acid ⟶ 2- and 3- carbon fragmenta
13	L-Leucine	α-Ketoisocaproic acid		α-Ketoisocaproic acid ⟶ isovaleric acid ⟶ acetoacetic acid
14	L-Lysine	α-Keto-ε-aminocaproic acid	Cadaverine	Lysine ⟶ α-aminoadipic acid ⟶ α-ketoadipic acid ⟶ glutaric acid; α-keto-ε-aminocaproic acid ⟶ dehydropicolinic acid ⟶ pipecolic acid
15	L-Methionine	α-Keto-γ-methiolbutyric acid		Methionine ⟶ homocysteine ⟶ (a) homocysteic acid; (b) H_2S, NH_3, α-ketobutyric acid; (c) + serine ⟶ cystathionine ⟶ cysteine + homoserine
16	L-Ornithine	α-Keto-δ-aminovaleric acid	Putrescine	Ornithine + NH_3 + CO_2 ⟶ citrulline
17	L-Phenylalanine	Phenylpyruvic acid	Phenylethylamine	Phenylalanine ⟶ (a) tyrosine (b) phenylpyruvic acid ⟶ phenylacetic and phenyllactic acids
18	L-Proline	α-Keto-δ-aminovaleric acid		Proline ⟶ (a) ornithine; (b) glutamic acid; (c) hydroxyproline
19	L-Serine	β-Hydroxypyruvic acid		Serine ⟶ NH_3 + pyruvic acid; serine + indole ⟶ tryptophan; see glycine
20	L-Threonine	α-Keto-β-hydroxybutyric acid		Threonine ⟶ NH_3 + α-ketobutyric acid
21	L-Tryptophan	β-Indolepyruvic acid	Tryptamine	Tryptophan ⟶ formylkynurenine ⟶ kynurenine ⟶ (a) kynurenic acid (b) anthranilic acid + alanine (c) 3-hydroxykynurenine ⟶ 3-hydroxyanthranilic acid ⟶ nicotinic acid
22	L-Tryosine	Para-hydroxyphenylpyruvic acid	Tyramine	Para-hydroxyphenylpyruvic acid ⟶ homogentisic acid ⟶ fumarylacetoacetic acid ⟶ fumaric acid + acetoacetic acid
23	L-Valine	α-Ketoisovaleric acid		α-Ketoisovaleric acid ⟶ isobutyric acid ⟶ 3 carbon fragment + CO_2

101. PATHWAYS OF PURINE AND PYRIMIDINE NUCLEOTIDE CATABOLISM

Nucleotides are composed of a purine or pyrimidine base linked to a pentose or desoxypentose sugar which, in turn, is linked to phosphate. Removal of the phosphate leaves a compound designated as a nucleoside. See table 102 for pathways of nucleoprotein catabolism in general.

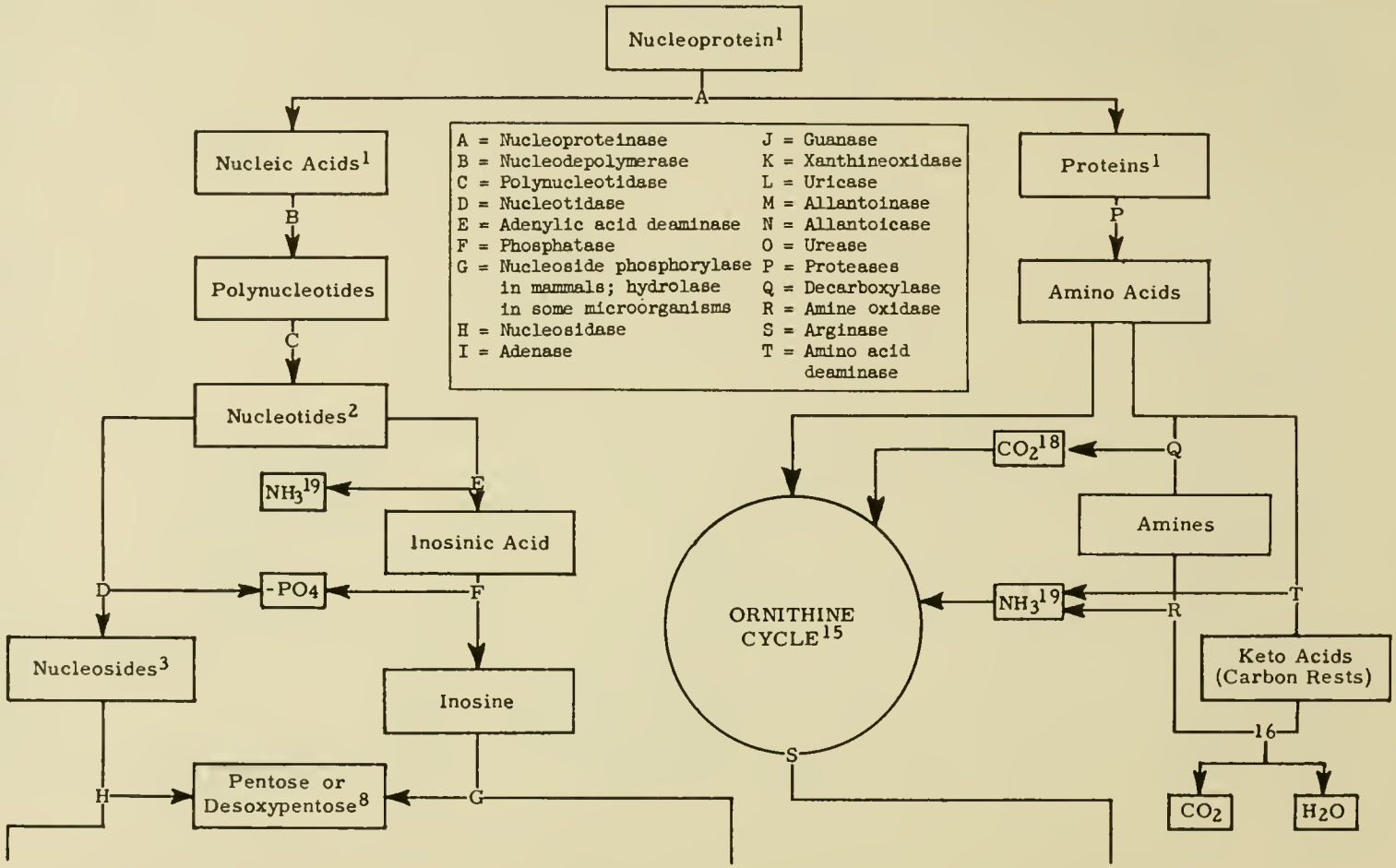
A = Phosphatase; B = Adenylic acid deaminase; C = Adenosine deaminase; D = Adenase?; E = Nucleoside phosphorylase; F = Xanthine oxidase; G = Guanylic acid deaminase; H = Guanosine deaminase; I = Guanase; J = Phosphorylase or hydrolase; K = Cytidine deaminase; L = Cytosine deaminase; M = Uracil-thymine oxidase; N = Barbiturase; O = Urease

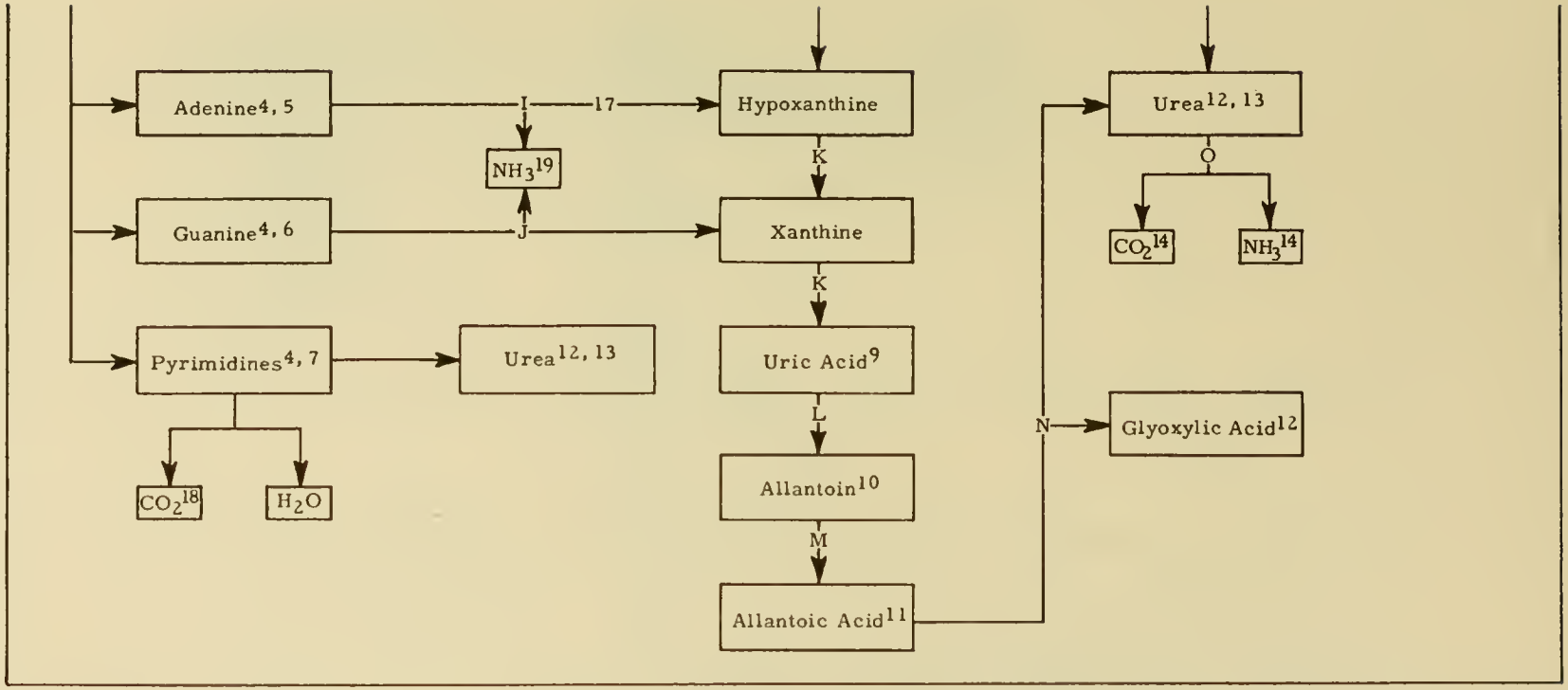


/1/ A purine derivative or contains purine ring. /2/ A purine. /3/ A pyrimidine derivative or contains pyrimidine ring. /4/ A pyrimidine. /5/ Demonstrated in yeast and E. coli. /6/ Thymine yields 5-methyl barbituric acid. /7/ Pathway demonstrated with Corynebacterium and Mycobacterium. /8/ In animal tissues; methyl uracil (thymine) yields β-aminoisobutyric acid. /9/ via: uric acid, allantoic acid, and glyoxylic acid. (cf. table 102). /10/ Urea is excreted as the end product of amino acid metabolism by mammals, and as an end product of purine and pyrimidine metabolism by most fishes, amphibia and fresh water lamellibranchs.

102. PATHWAYS OF NUCLEOPROTEIN CATABOLISM

Nucleoproteins generally are composed of basic proteins, histones or protamins, associated with nucleic acids. The nucleic acids are complex molecules, each composed of many nucleotide units, joined by phosphate sugar linkages. Each nucleotide is made up of a purine or pyrimidine base, linked to a pentose or desoxypentose, and this in turn to a molecule of phosphoric acid, Upon hydrolysis of the nucleotide in the digestive tract or tissues, the phosphoric acid is removed. The remaining compound, a nucleoside, contains the purine or pyrimidine base and the sugar residue.

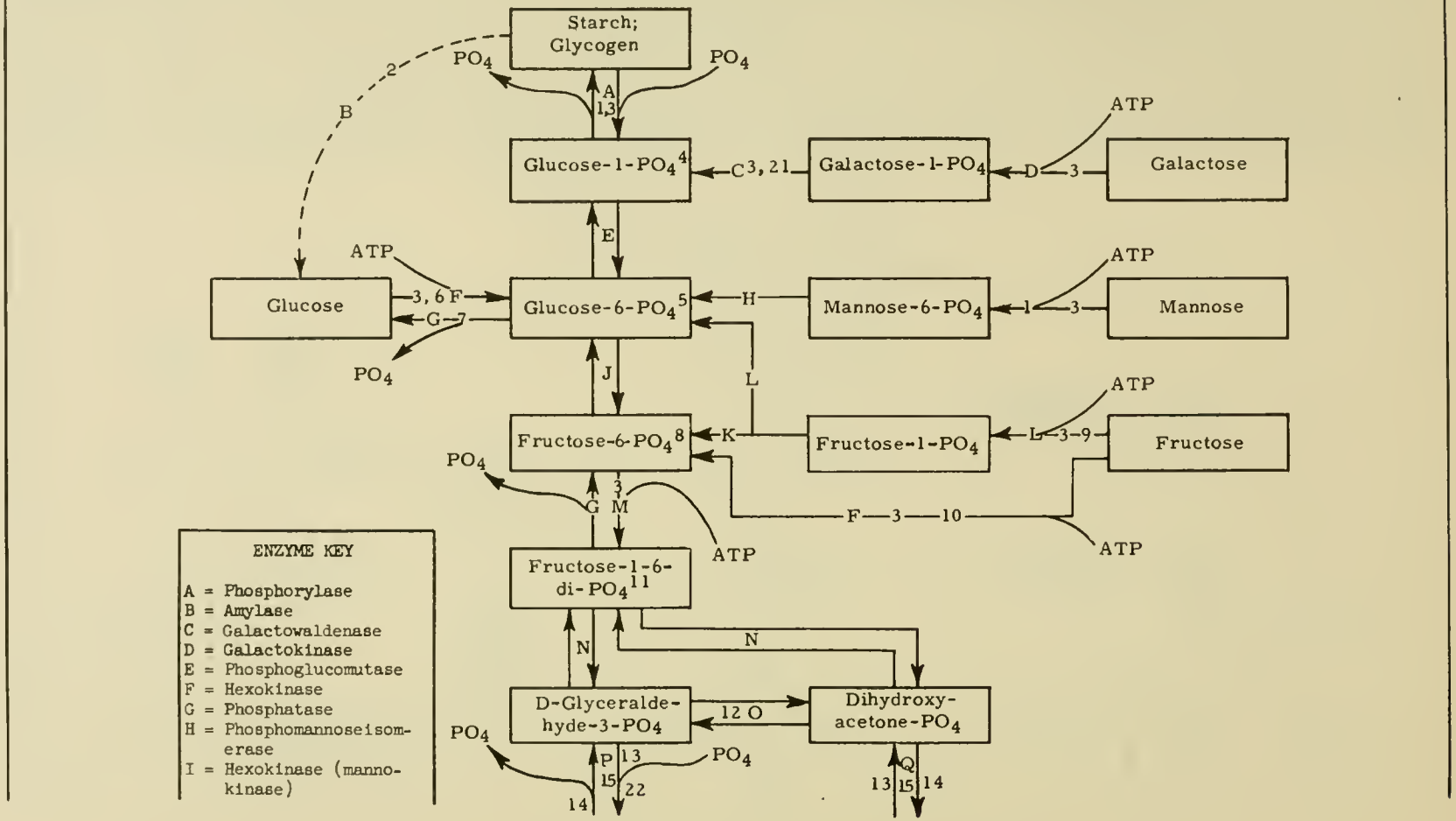


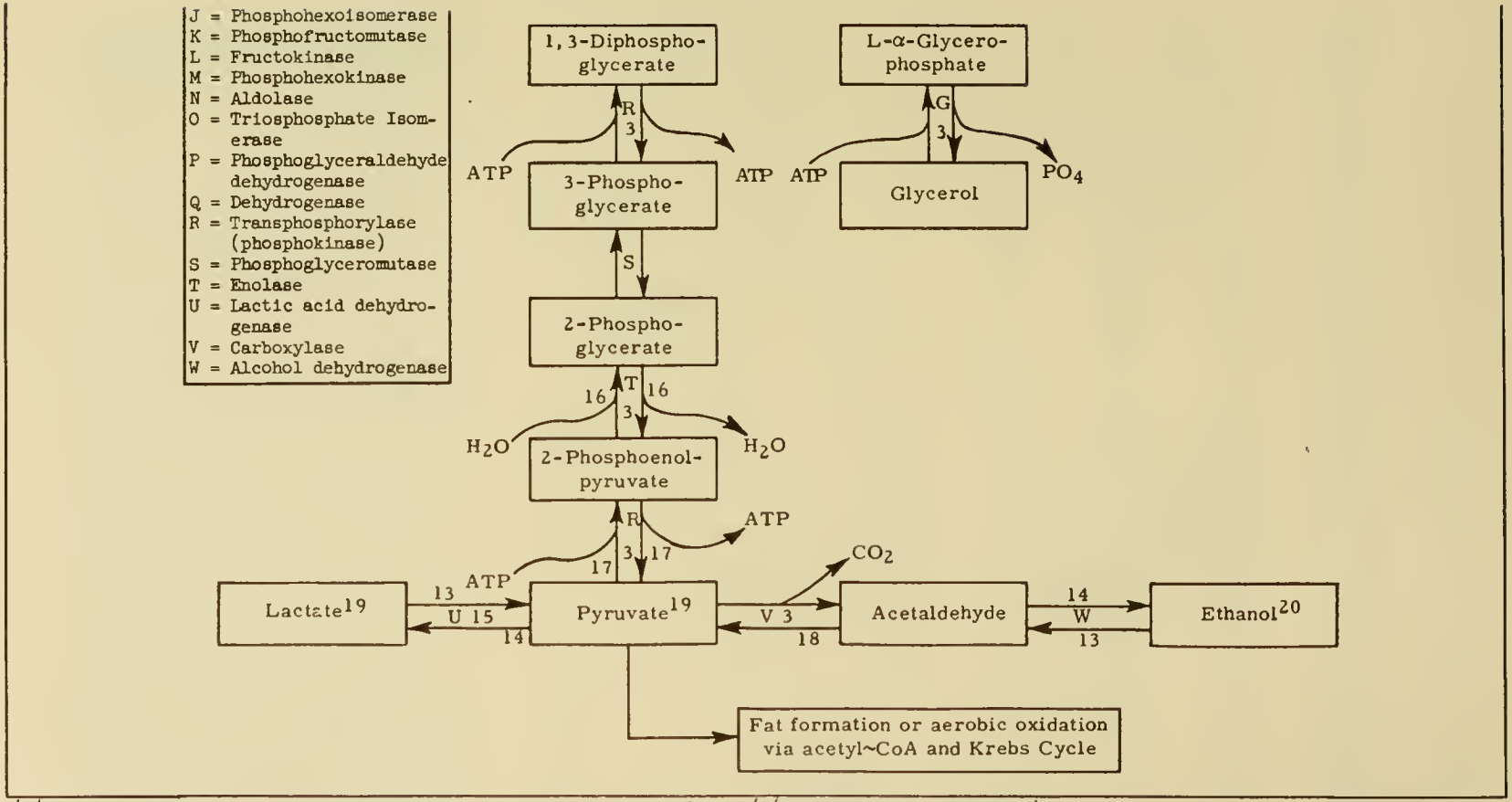


/1/ Catabolism of nucleoprotein, nucleic acid, and protein may take place in the alimentary canal or in the tissues. See table 101 for detailed pathways of purine and pyrimidine nucleotide catabolism. /2/ Some intestinal absorption. Nucleotidase in liver splits both pyrimidine and purine nucleotides to nucleosides. /3/ Absorbed in the intestine. Purine nucleosides are split into purines and pentoses by purine nucleosidase present in tissues. /4/ Mammals do not require exogenous purines or pyrimidines, but can synthesize them from products of protein metabolism. /5/ Adenine and guanine are the only naturally occurring purines in nucleic acids. /6/ Excreted by pig and spider. /7/ Little is known about the stages in pyrimidine catabolism. It is thought that pyrimidine nitrogen is largely converted to urea, indicating disruption and metabolism of the pyrimidine ring. (cf. table 101) /8/ D-Ribose and D-2-desoxyribose have been definitely established as present in nucleoproteins; other pentoses may be present. /9/ Excreted as end product of purine catabolism by primates, Dalmatian dog, some reptiles, some insects;and as end product of catabolism of proteins as well as purines and pyrimidines by birds (no urea formation by birds). /10/ Excreted by most mammals, gastropods,and some insects. /11/ Excreted by some teleost fishes. /12/ Excreted by most fishes, amphibia, fresh water lamellibranchs. /13/ Urea is excreted as the end product of amino acid metabolism by mammals, and as an end product of purine (and pyrimidine?) metabolism by some other forms (cf. Fn. 12). /14/Crustacea, gephyrean worms, marine lamellibranchs do not excrete urea but break it down to CO_2 and NH_3 which are excreted./15/Urea formation in the mammalian liver is via the "Ornithine Cycle" (Krebs-Henseleit Cycle"). The pathway through the cycle is: ornithine ⟶ citrulline ⟶ arginine succinate ⟶ arginine ⟶ ornithine. CO_2 and NH_3 enter the cycle at ornithine,NH_3 and aspartic acid at citrulline. Arginine succinate is split to arginine and fumaric acid, after which arginine is converted to ornithine with the release of urea. /16/ Via Krebs Cycle (cf. table 106). In the course of amino acid metabolism, previous to entry into the Krebs Cycle, sulfur-containing amino acids lose their sulfur -- usually in the form of SO_4. /17/ There is little likelihood that the route adenine ⟶ hypoxanthine is of any importance in animals. Adenase is not found to any extent in mammals. /18/ May enter into metabolic processes, into the Ornithine Cycle and be incorporated into and excreted as urea,or be excreted as such. /19/May be built into amino acids,incorporated into urea and excreted,or excreted as such across the kidney tubule(in appropriate animal species).

103. PATHWAYS OF CARBOHYDRATE METABOLISM: GLYCOLYSIS

The pathway from stored or ingested carbohydrate to pyruvate is one of release of stored energy by anaerobic oxidation (glycolysis). Released energy is partly dissipated as heat and partly stored (temporarily) in the labile energy pool as "high energy phosphate" ($\sim PO_4$) by combination of $\sim PO_4$ with continuously available ADP (adenosine diphosphate) to form ATP (adenosine triphosphate). In the conversion of 1 mole of glucose (180 g) or of other monosaccharide to 2 moles of pyruvate (174 g), 2 moles of ATP are converted to ADP and 4 moles are formed from ADP, making a net gain of 2 moles of ATP, equivalent to 24 kilocalories of readily available energy. If glucose-6-PO_4 has come from metabolic breakdown of glycogen, the cost is only 1 mole of ATP, making a net gain of 3 moles of ATP (36 kilocalories). The ATP is an immediate source of energy whose utilization (e. g. for muscular activity) is independent of oxygen supply. Aerobic oxidation (to carbon dioxide and water) begins where the present pathway ends and yields an additional 650 kilocalories per mole of hexose (cf. table 106, The Krebs Cycle).

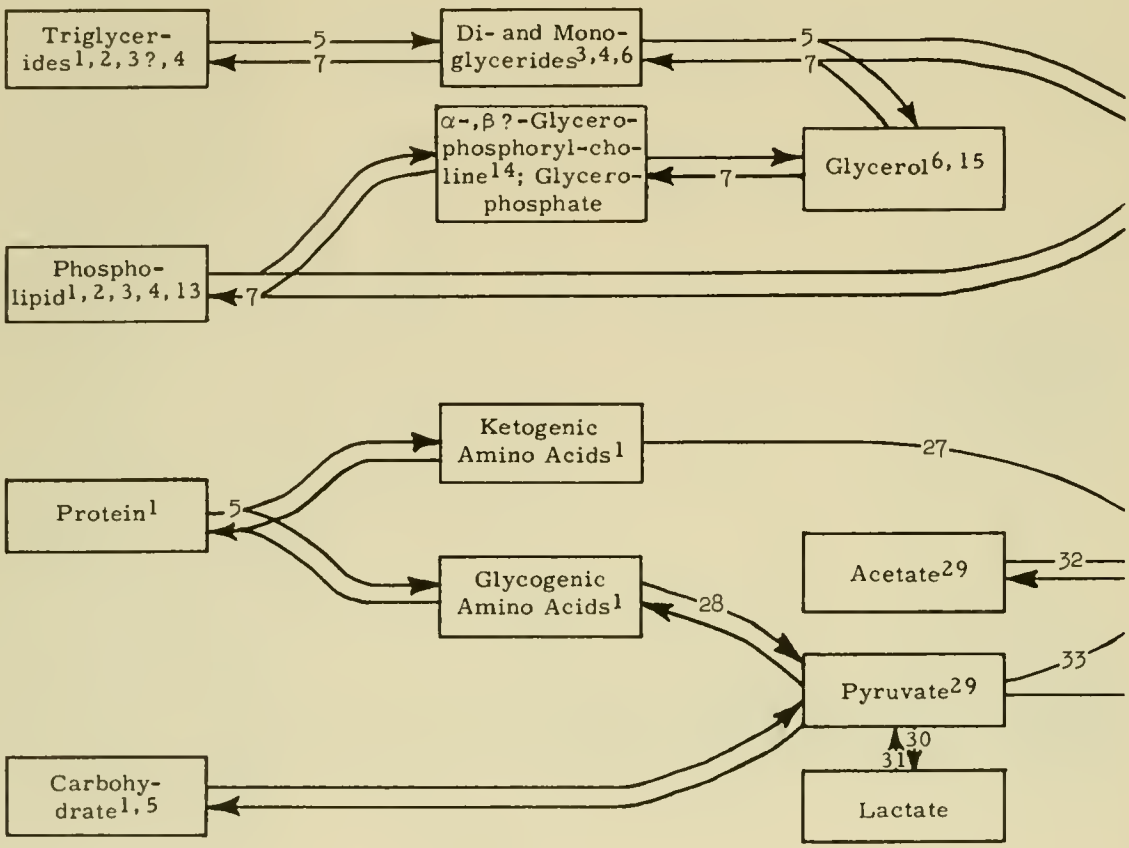




/1/ Adenylic acid and PO_4 required for activity in either direction. /2/ Digestion; glycogen and/or starch hydrolyzed to glucose in intestinal lumen. /3/ Mg^{++} required for this reaction. /4/ "Cori Ester". /5/ "Robison Ester". /6/ "Hexokinase reaction," inhibited by growth hormone plus adrenal cortex hormone; and inhibition by these substances blocked by insulin, which thus favors conversion of glucose to glucose-6-phosphate. /7/ The reaction: glycogen to glucose-6-PO_4 to blood glucose, takes place in liver only; conversion of glucose to glucose-6-PO_4 to glycogen takes place in liver, muscle, and other tissues. /8/ "Neuberg Ester". /9/ In liver and muscle. /10/ In all tissue. /11/ "Harden-Young Ester". /12/ This reaction (to left) causes each step in the conversion to pyruvate to be doubled quantitatively; thus 1 mole of glucose gives rise to 2 moles of pyruvate. /13/ Hydrogen ions released. /14/ Hydrogen enters into the reaction. /15/ DPN acts as acceptor of released hydrogen ions, becoming $DPNH_2$, in oxidative direction of the reaction; $DPNH_2$ gives up hydrogen ions, becomes DPN, in reverse direction. Hydrogen ions accepted by DPN passed on in turn, to flavoprotein, cytochrome-c, cytochrome oxidase, molecular O_2. If molecular O_2 not sufficiently available, hydrogen ions may be passed from $DPNH_2$ to pyruvate forming lactate. /16/ Inhibited by fluoride. /17/ K^+ also required. /18/ Thiamine pyrophosphate is required as coenzyme. /19/ Pyruvate, followed by conversion to lactate when oxygen supply is deficient (cf. Fn 15), ends glycolysis in animal tissues. If oxygen is available pyruvate is oxidized via the Krebs Cycle, q. v. /20/ End of fermentation plant tissue. /21/ Uridine diphosphate glucose required as coenzyme. /22/ Inhibited by iodoacetate.

104. PATHWAYS OF LIPID METABOLISM: MAMMALS

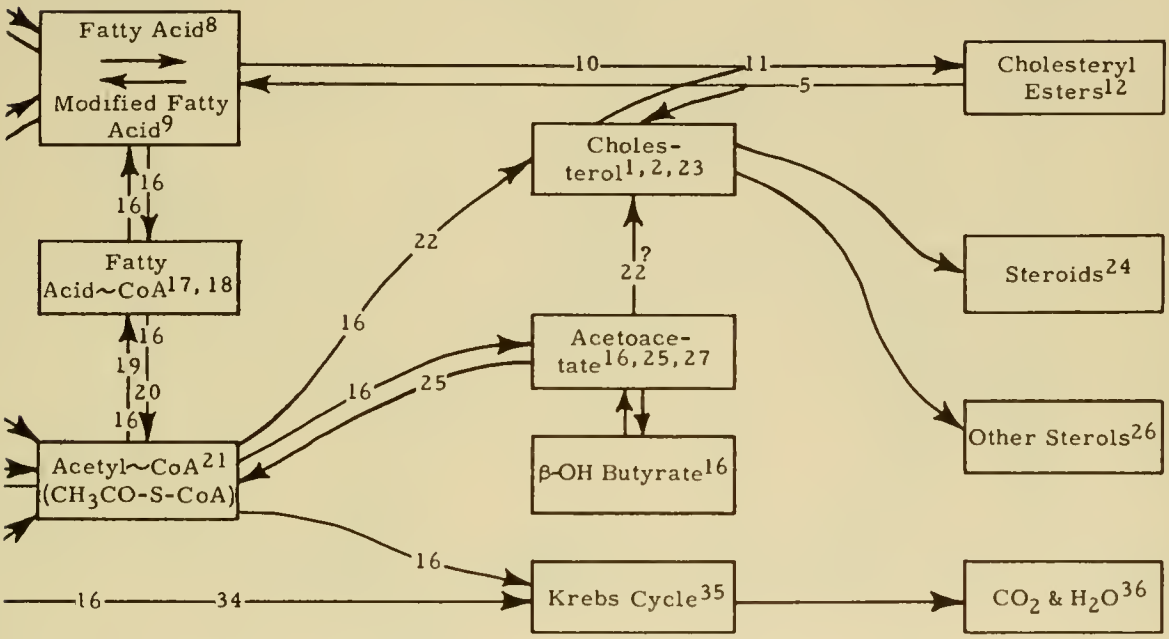
These pathways are believed to occur in the lipid metabolism of animal forms in general. They are based on studies confined chiefly to mammals.



/1/ In intestinal lumen, blood, liver, other tissues. /2/ In chyle. /3/ Some absorption by intestinal mucosa. /4/ Formed in intestinal mucosa,or absorbed from lumen, pass into chyle, short chains possibly also into portal blood. /5/ Digestion in intestinal lumen. /6/ Probably transitory in tissues. /7/ In intestinal mucosa, liver, other tissues. /8/ Occur free (ionized) in intestinal lumen, blood, liver; free existence in chyle, questioned; free existence probably transitory in other tissues, if it occurs. /9/ In liver, carbon chains lengthened or shortened (cf. Fn 20), and H added to C_{9-10}, or removed creating double bonds. /10/ Chiefly (?) unsaturated. /11/ Synthesis probably in intestinal mucosa, liver, blood. /12/ In chyle, blood, and small amounts in liver, other tissues; not in brain, red cells. /13/ Chiefly lecithin, cephalins (phosphatides of ethanolamine, serine, inositol, acetal, and polyglyceride phosphatides) some sphingomyelin. /14/In intestinal mucosa, liver (?), other tissues (?). Split to choline, glycerol, phosphoric acid. /15/ In intestinal lumen, absorbed by intestinal mucosa, where resynthesized into glycerides, including phospholipids. Metabolized to pyruvate. /16/ In liver, other tissues. /17/ Fatty acid ester of coenzyme A, i. e., acyl~CoA ester, formed by ATP-dependent acylation of CoA or by transfer of CoA from succinyl- or other CoA ester. /18/ Coenzyme A probably = pantetheine (pantothenic acid + β-alanine + thioethanolamine) + ADP, with a third PO_4 at C_3 of the ribose; forms fatty acid thiol esters via the SH in the thioethanolamine. /19/ Reverse of β-oxidation (cf. Fn 20). Retarded or

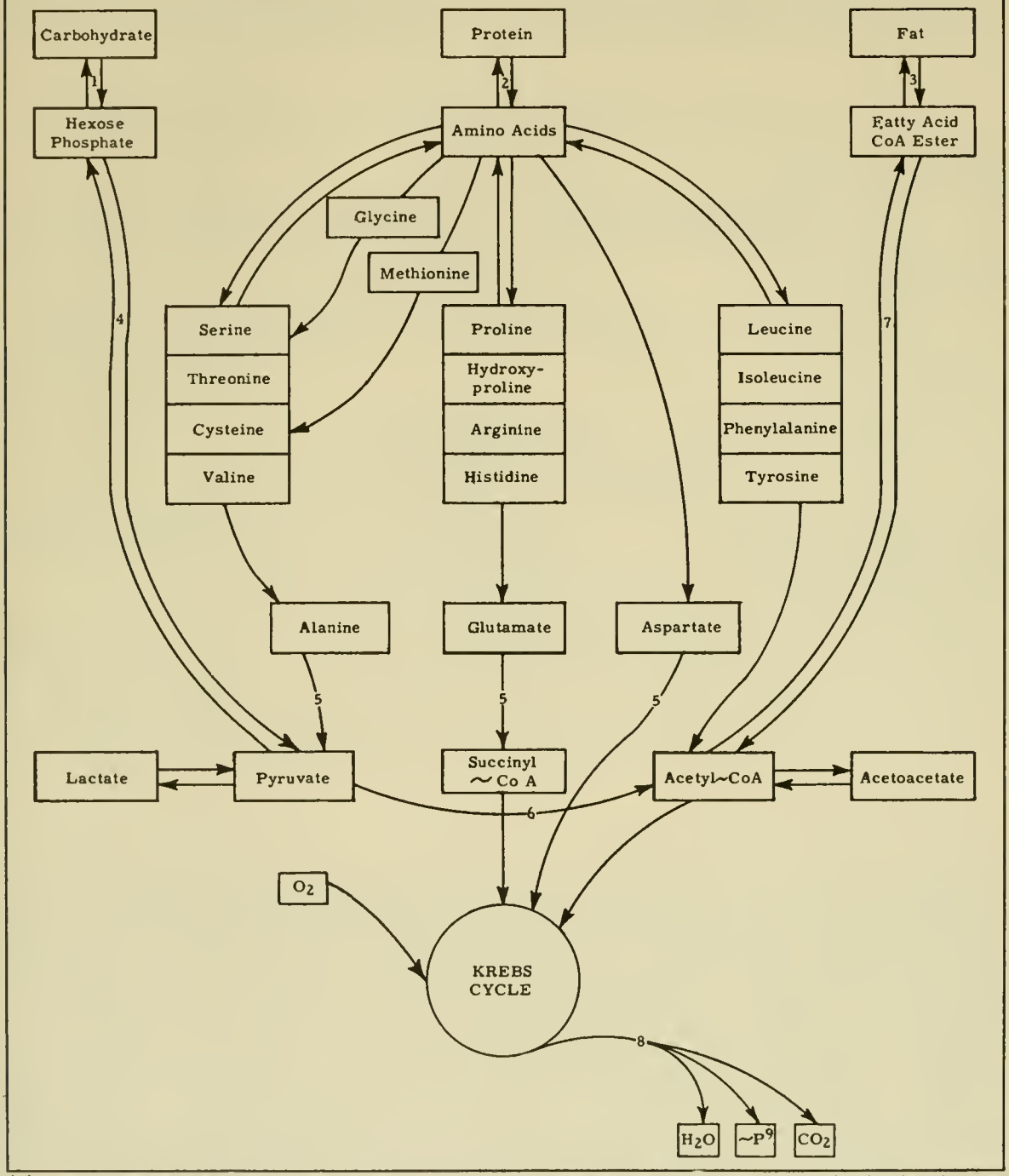
104. PATHWAYS OF LIPID METABOLISM: MAMMALS (Concluded)

These pathways are believed to occur in the lipid metabolism of animal forms in general. They are based on studies confined chiefly to mammals.



blocked in diabetes mellitus, starvation (?). Insulin useful, probably necessary, but site of lipogenic action not known -- possibly the hexokinase reaction in carbohydrate metabolism. /20/ Fatty acid-CoA ester shortened 2 carbons at a time by β-oxidation, breaking off a molecule of acetyl~CoA at each step, and re-esterifying the remainder with CoA. /21/ Acetic acid ester of coenzyme A known also as S-acetyl coenzyme A, active acetyl. /22/ Via squalene? /23/ Adrenal steroids (C_{11}oxy) promote synthesis (?). /24/ Hormones, bile acids. /25/ Transported from liver via blood to other tissues, where oxidized, via acetyl~CoA and Krebs Cycle, to CO_2 and H_2O. Some conversion to acetone. /26/ Coprosterol, epicoprosterol excreted. /27/ Tyrosine, leucine, isoleucine also converted directly to acetoacetate. /28/ Aspartate enters Krebs Cycle not via pyruvate, but by conversion directly to oxalacetate. /29/ Occurs in blood, liver, muscle, other tissues. /30/ Occurs in muscle, especially in exercise, the lactate diffusing into the blood stream. /31/ Occurs in liver, muscle, brain, other tissues. /32/ ATP-dependent reaction with CoA. /33/ Diphosphothiamine (= cocarboxylase), lipoic acid, Mg^{++} required. /34/ Pyruvate + CO_2 ⟶ oxalacetate, malate, components of Krebs Cycle. Oxalacetate condenses with acetyl~CoA, to form citrate. This removal of acetyl~CoA by oxalacetate (i. e., by pyruvate), occurring when acetyl~CoA is being formed in active fat catabolism, may explain antiketogenic action of carbohydrate (and protein). /35/ For Krebs Cycle see table 106. /36/ And energy liberation.

105. METABOLIC INTERRELATIONSHIPS: CARBOHYDRATE, FAT, AND PROTEIN

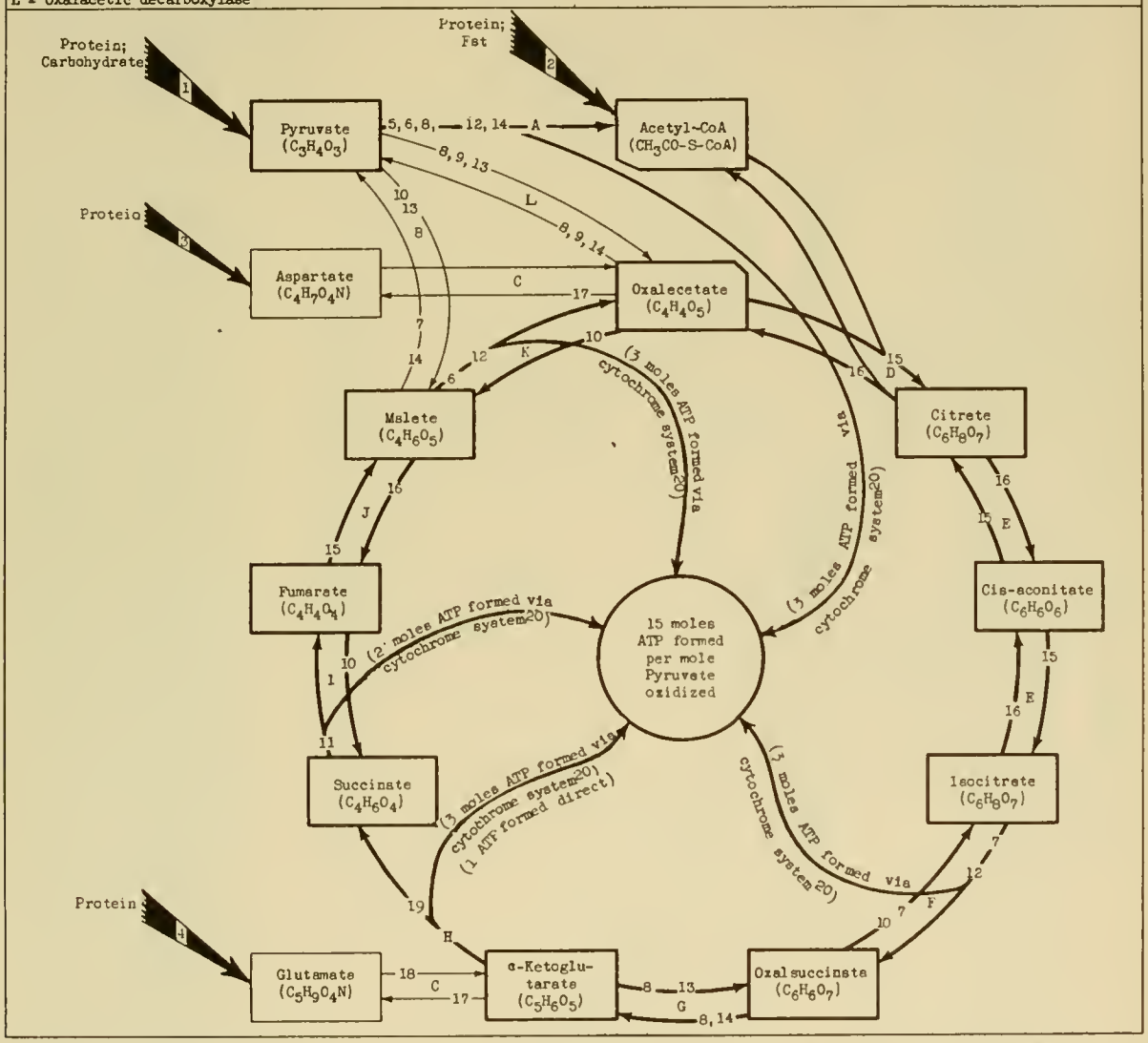


/1/ Phosphorylase and PO_4 phosphorylate hexose units in stored polysaccharides; hexokinase and ATP phosphorylate hexoses. /2/ Proteolysis by proteases in digestive tract or tissues. Synthesis by proteases of tissues. /3/ Lipase splits fat into fatty acids and glycerol; glycerol, via glycerol phosphate and dehydroxy acetone phosphate, enters the glycolytic cycle. Fatty acid then is acted upon by coenzyme A. /4/ Glycolysis. /5/ Oxidative deamination. /6/ Decarboxylation. /7/ β-oxidation. /8/ Chain of electron-transmitting enzymes. /9/ "High energy" phosphorus.

106. THE KREBS CYCLE

The Krebs Cycle (tricarboxylic acid cycle) is a major pathway for the final (aerobic) oxidation of carbohydrates, fats, and proteins. These three nutrients are channeled into the cycle via their two key metabolites, pyruvate and acetyl~CoA ("active acetate"). Each "revolution" of the cycle oxidizes 1 mole (59 g) of acetate to CO_2 and H_2O, with release of approximately 200 kilocalories of energy. A portion of the released energy (approximately 144 kilocalories) enters the phosphate energy pool as ATP. Twelve moles of ATP are formed from ADP and PO_4 (by energizing PO_4 to ~PO_4). The remainder of the released energy appears as heat. Oxidation of 1 mole (87 g) of pyruvate, proceeding via acetyl~CoA, contributes a total of 15 moles of ATP to the energy pool.

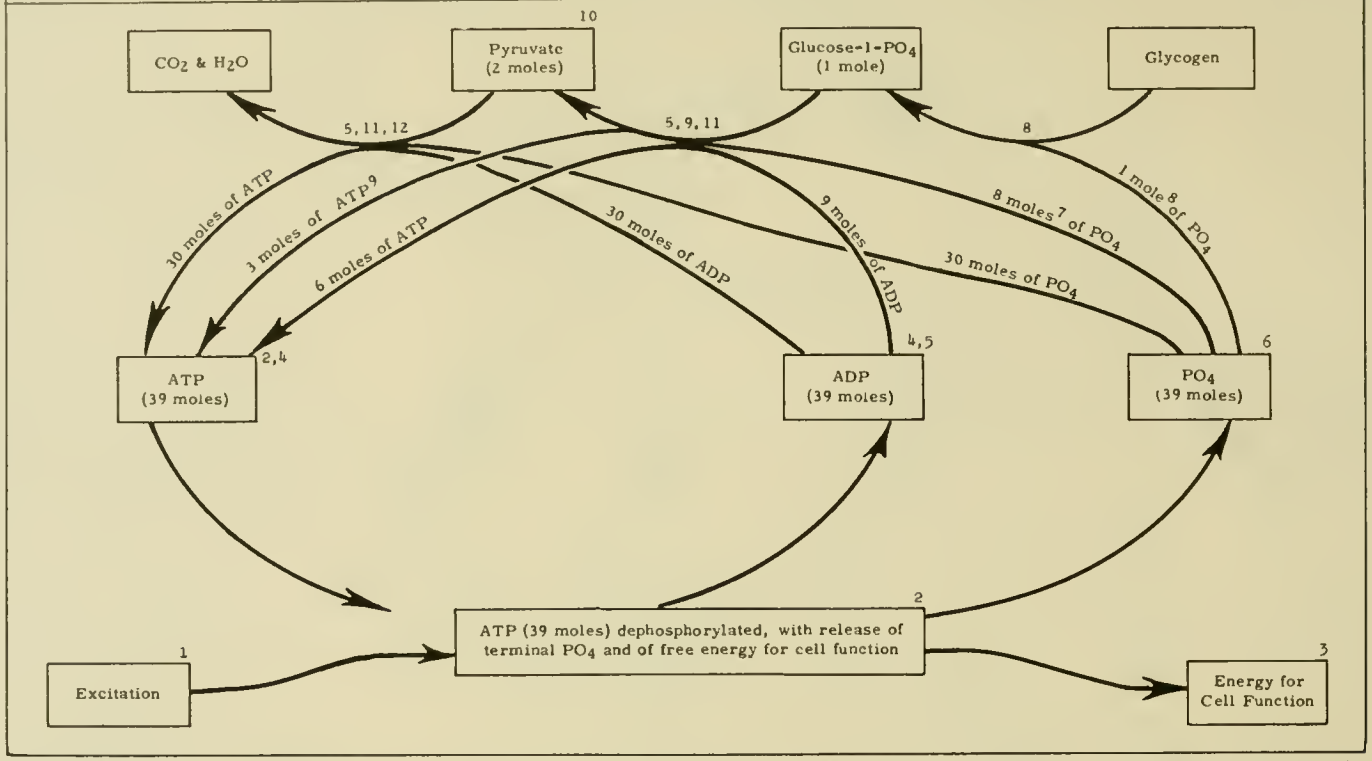
A = Pyruvic decarboxylase; B = Malic enzyme; C = Transaminase; D = Condensing enzyme; E = Aconitase; F = Isocitric dehydrogenase; G = Oxaloscuccinic carboxylase; H = α-Ketoglutaric dehydrogenase; I = Succinic dehydrogenase; J = Fumarase; K = Malic dehydrogenase; L = Oxalacetic decarboxylase



/1/ Glucogenic amino acid precursors for pyruvate are: alanine, glycine, serine, threonine, methionine, cysteine, valine. /2/ Ketogenic amino acid precursors for acetyl~CoA are: leucine, isoleucine, phenylalanine, tyrosine. /3/ Aspartic acid occurs as a component of protein. /4/ Glutamic acid occurs as a component of protein or may be formed from: arginine, proline, hydroxyproline, histidine, ornithine. /5/ Coenzyme-A (= ATP-pantoyl-β-alanyl-thioethanolamine) and α-lipoic acid required. /6/ In the oxidative direction, DPN (= diphosphopyridine nucleotide, a compound of nicotinamide, D-ribose, H_3PO_4 and adenine; also known as coenzyme I) acts as hydrogen acceptor; in the reverse direction $DPNH_2$ is hydrogen donor. /7/ In the oxidative direction, TPN (= triphosphoryridine nucleotide; coenzyme II) acts as hydrogen acceptor; in the reverse direction, $TPNH_2$ is hydrogen donor. /8/ DPT (= diphosphothiamine; thiamine pyrophosphate; cocarboxylase) required as coenzyme for the carboxylase (A); also Mg^{++}, or Mn^{++} is required as activator for the enzyme. /9/ Biotin required as coenzyme for decarboxylation. /10/ 2H enters into the reaction. /11/ 2H released and their electrons transferred to cytochrome. /12/ Hydrogen ions transferred to DPN (or, in the case of isocitrate ⟶ oxalsuccinate, to TPN) and pass in turn to flavoprotein, cytochrome-c, cytochrome oxidase, and finally to combination with molecular oxygen. For each H thus passed and finally oxidized, 1.5 moles of ATP are formed by the addition of energized phosphate (~PO_4) to ADP. /13/ CO_2 enters into the reaction. /14/ CO_2 released. /15/ H_2O enters into the reaction. /16/ H_2O released. /17/ NH_3 enters into the reaction by transamination. /18/ NH_3 transferred from glutamate by transamination, then enters into Krebs Cycle via succinyl ~ CoA. /19/ Footnotes 5, 6, 8, 12, 14 apply to this reaction. /20/ For details of cytochrome system, see table 108.

107. ACTIVITY-METABOLISM: MUSCLE

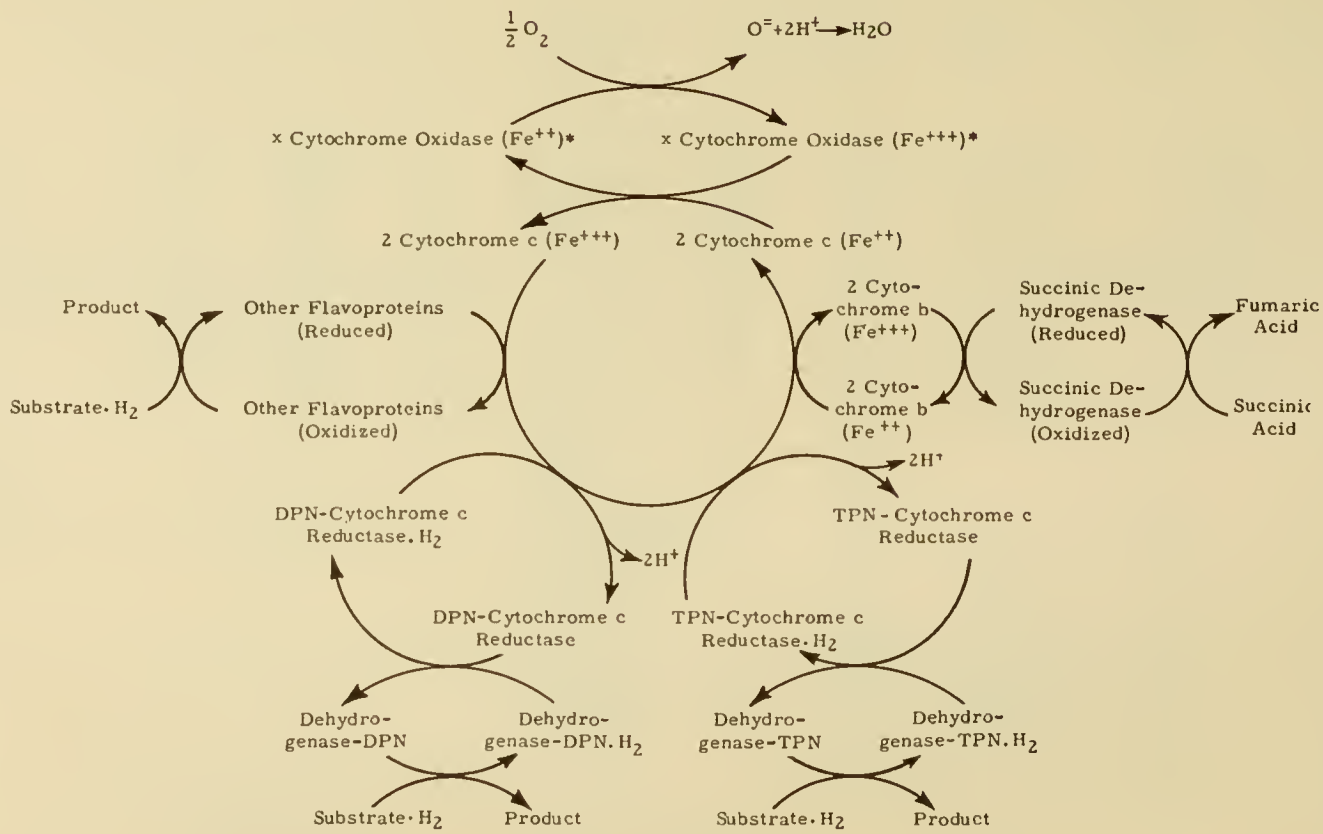
Excitation of the muscle (cell) is accompanied by reversal of polarity of the cell membrane. The first identifiable metabolic event to follow is dephosphorylation of ATP. The breaking off of the terminal PO_4 of ATP is accompanied by release of energy previously stored in the molecule. The compound, minus one phosphate, is left as ADP. This compound is an acceptor of phosphate to form "high energy carrier." If the presence of such acceptor is viewed as the stimulus to the subsequent steps in activity-metabolism, the presence of ADP causes progression of glucose-1-PO_4 to pyruvate (or to lactate if $DPNH_2$ has accumulated due to inadequacy of O_2 supply), and also brings about the progression of pyruvate to CO_2 and H_2O. In so doing, ADP is reconverted to ATP, (and other phosphate-acceptors that may be present are similarly rephosphorylated). The stimulus to extra release of energy from carbohydrate stores thus disappears, and the cell returns to its basal state of respiration and energy release.



/1/ "When the stimulus is withdrawn, respiration continues at the elevated rate only until the organ is restored to its original state....With no compounds remaining in the unphosphorylated state, the respiratioc machinery stops with the various enzymes blocked in the acylated and/or phosphorylated states." /2/ The quantity of ATP assumed, 39 moles, is adjusted to the catabolism of 1 mole of glucose-1-PO_4 or 1 mole of 6-carbon unit, component of glycogen. /3/ Approximately 13-16 kilocalories of free energy per mole of ATP cooverted to ADP,or 500-600 kilocalories for the quantities represented in the diagram. Energy used for muscle contraction, and for synthesis. /4/Other high energy carriers than ATP (adenosine triphosphate) and other phosphate acceptors than ADP (adenosine diphosphate) may also function (e.g. creatine phosphate and creatine--also phosphates of guanosine, cytidine and uridine). /5/ Rate of energy release from stored carbohydrate probably controlled by concentration of phosphate acceptors capable of forming high energy carriers (cf. Fn 4). /6/ Is inorganic phosphate pool. /7/ These 8 moles include 2 that combine with 2 moles of D-glyceraldehyde-3-phosphate (= "substrate phosphorylation") and are then transferred to ADP; and 6 that combine directly with ADP in association with the oxidatioo of 4 moles of hydrogeo ion previously released by 1,3-diphosphoglycerate to DPN (to form $DPNH_2$; = "electron transport phosphorylation"--see table 108, also Fn 15, table 103). /8/ One PO_4 combines with one 6-carbon unit in glycogen to form glucose-1-PO_4, with no appreciable energy change. /9/ Not shown in diagram: One mole of ATP is required at an early step in the reaction: glucose-1-PO_4 → pyruvate, and 4 moles of ATP are formed at later steps. The net gain is 3 moles of ATP. The 3 moles of PO_4 have come from the 1 mole combined into glucose-1-phosphate (cf Fn 8) and 2 of the 8 moles covered by Fn 7. /10/ Pyruvate is converted to lactate by reaction with $DPNH_2$, if the latter has accumulated, as in conditioos of relative oxygen deficiency. /11/ Energy from carbohydrate metabolites is built into the ATP molecule. /12/ Via Krebs Cycle.

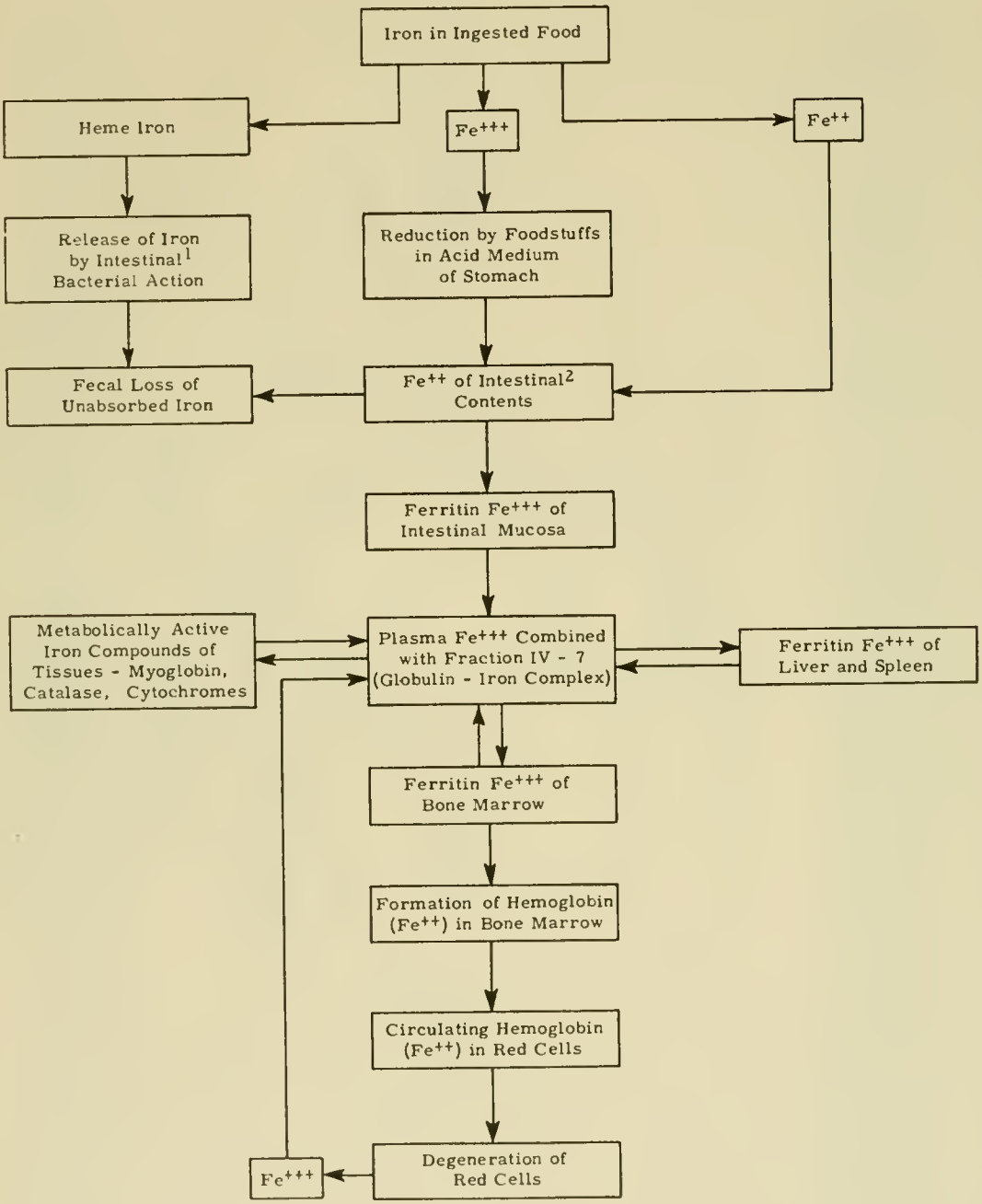
108. THE CYTOCHROME SYSTEM

The cytochromes (iron-containing compounds) in association with certain other compounds constitute the "Cytochrome System". The system operates as the final pathway by which an intermediate metabolite ("substrate"), under the influence of its specific dehydrogenase, releases hydrogen to the first member in a series of carriers for ultimate combination with oxygen to form water. Each step in the process involves both oxidation and reduction: The cytochrome system oxidizes the hydrogen of the substrate by removing electrons from it, thereby producing oxidized substrate and hydrogen ions, and the system itself is reduced in the process and is finally oxidized by molecular oxygen. For each gram of hydrogen thus passed and finally oxidized enough energy is produced to form 1.5 moles of ATP from ADP and PO_4.



*Cytochrome a and cytochrome a_3 have not been proved to be separate enzymes. For the present, therefore, there is only one enzyme that acts between cytochrome c and molecular oxygen. This component is termed cytochrome oxidase.

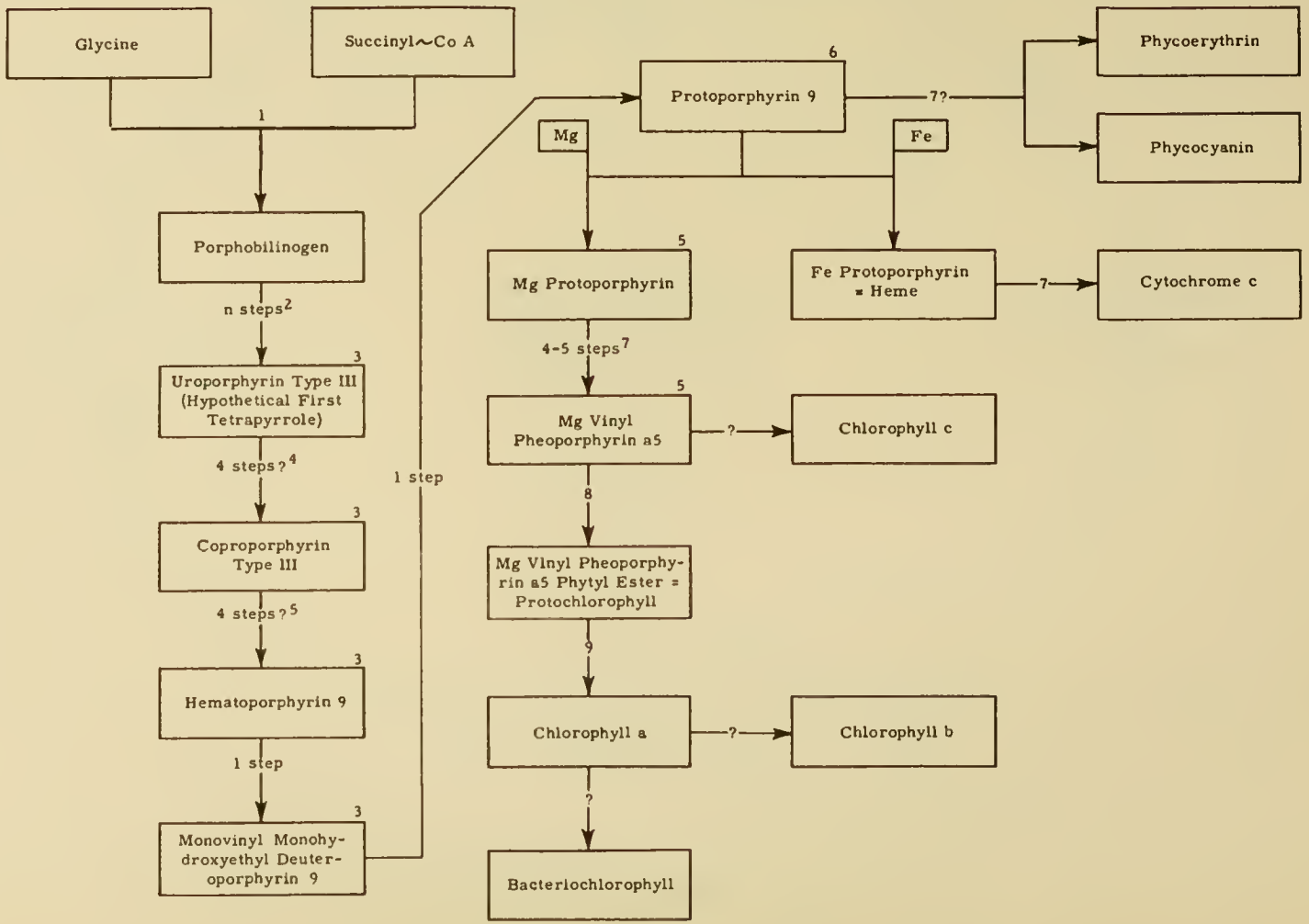
109. PATHWAYS OF IRON METABOLISM: MAMMALS


Iron in Ingested Food
Heme Iron
Fe+++
Fe++
Release of Iron by Intestinal[1] Bacterial Action
Reduction by Foodstuffs in Acid Medium of Stomach
Fecal Loss of Unabsorbed Iron
Fe++ of Intestinal[2] Contents
Ferritin Fe+++ of Intestinal Mucosa
Metabolically Active Iron Compounds of Tissues - Myoglobin, Catalase, Cytochromes
Plasma Fe+++ Combined with Fraction IV - 7 (Globulin - Iron Complex)
Ferritin Fe+++ of Liver and Spleen
Ferritin Fe+++ of Bone Marrow
Formation of Hemoglobin (Fe++) in Bone Marrow
Circulating Hemoglobin (Fe++) in Red Cells
Degeneration of Red Cells
Fe+++

/1/ Large intestine. /2/ Small intestine.

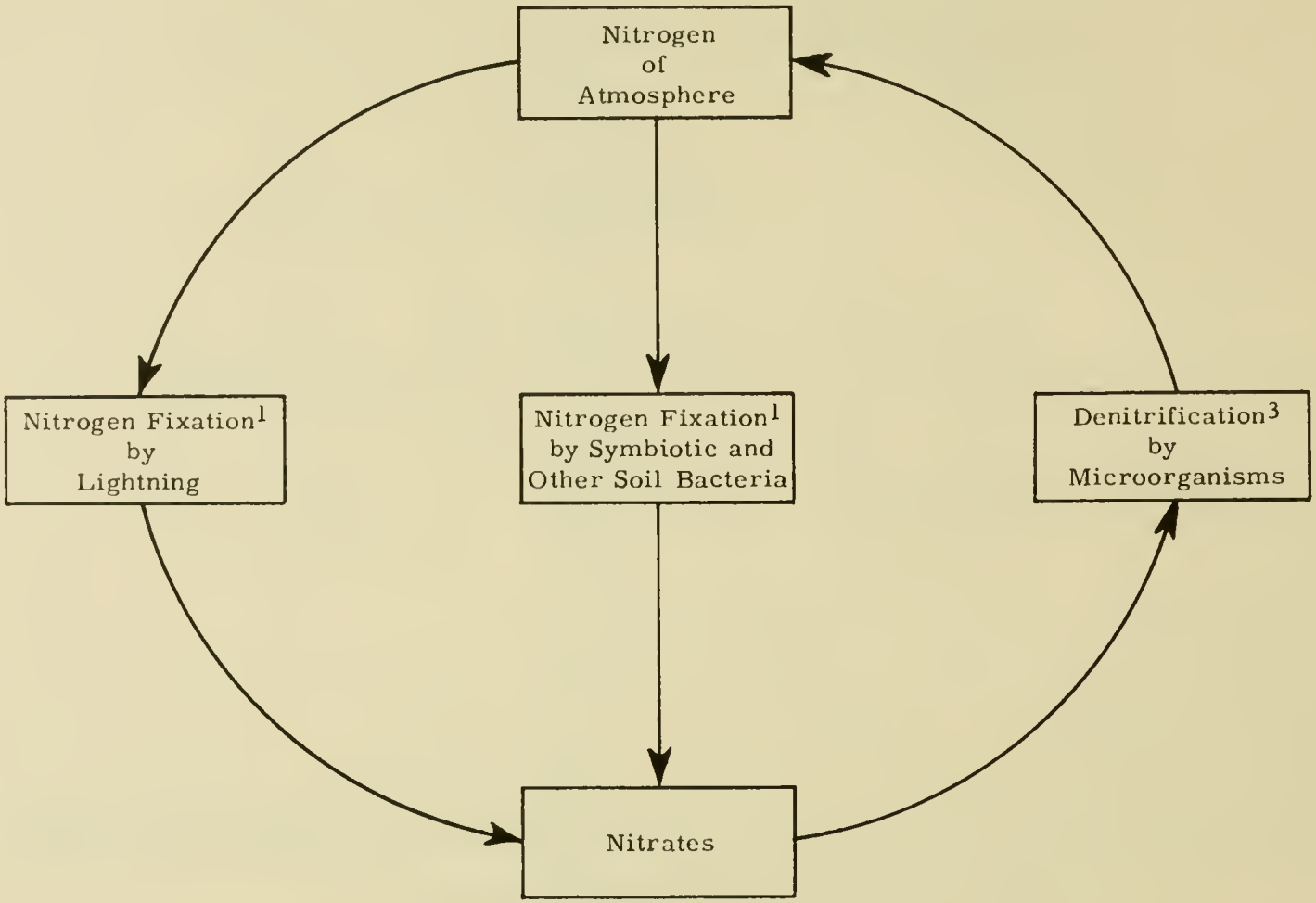
110. PATHWAYS OF CHLOROPHYLL SYNTHESIS

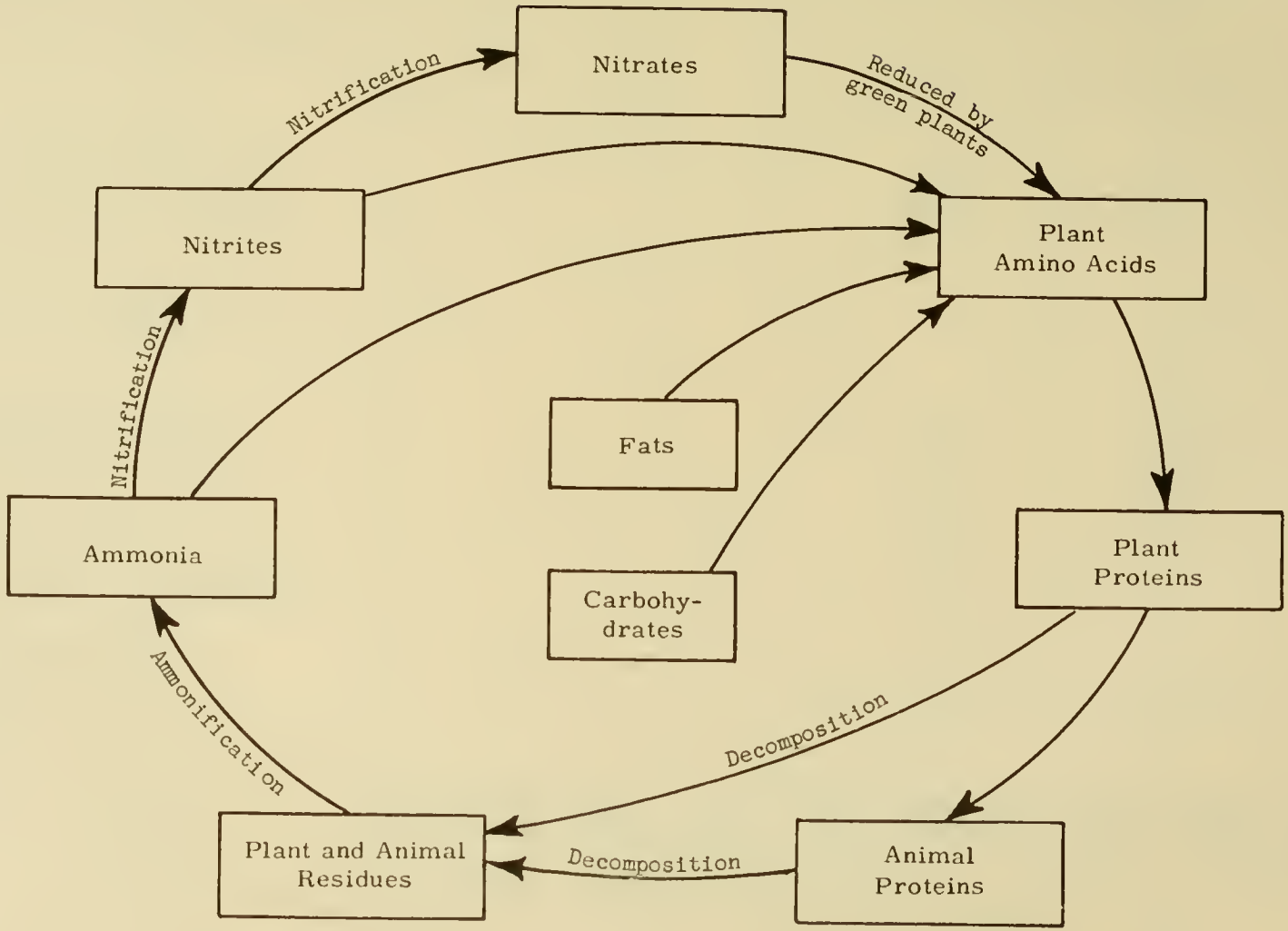
The diagram summarizes present knowledge and theory of the pathways leading to synthesis of chlorophyll by plants. The probable relationship of synthesis of cytochrome-c (and other heme enzymes) is also indicated.



/1/ Glycine + succinyl Co A ⟶ α-amino β-keto adipic acid. This compound is then synthesized into δ-amino-levulinic acid, precursor for porphobilinogen. /2/ Four porphobilinogen molecules postulated to unite to form uroporphyrin Eight glycine molecules and eight molecules of succinyl~Co A have participated. /3/ Found in a chlorella mutant. /4/ Uroporphyrin decarboxylated to coproporphyrin. /5/ Coproporphyrin converted by oxidation to hematoporphyrin and next two compounds. /6/ Found in a chlorella mutant devoid of chlorophyll and carotenoids. /7/ Four or five steps postulated to include reduction of vinyl side chain to ethyl; oxidation of a propionic acid group and esterification with methyl alcohol and cyclization to form the cyclopentanone ring. /8/ A propionic acid group is esterified with phytol (a C20 alcohol). /9/ Protochlorophyll reduced at pyrrole ring IV.

111. THE NITROGEN CYCLE IN NATURE





/1/ Atmospheric nitrogen is converted into nitrates. /2/ Bacteria living in root cells of leguminous plants. /3/ Nitrates are converted into gaseous nitrogen oxides or into free nitrogen.

112. PARTITION OF EXCRETED NITROGEN: ANIMALS (Section I)

(See p. 202ff for columns L-T of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted.

	Species	Allantoin-N		Amino Acid-N		Ammonia-N		Creatine-N		Creatinine-N	
		Value	Range	Value	Range	Value	Range	Value	Range	Value	Range
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	VERTEBRATA										
	Mammalia										
1	Man (Homo sapiens)[1,2]					4.8	3.2-5.1			3.6	
2								3.1-4.9			
3	Alpaca (Auchenia vicunna)[1,3]					4.5		2.7?		4.6	
4	Bat (Xantharpyia (spp.))[1,2]			0.96		6				8.5	
5								8.5			
6	Camel, bactrian (Camelus bactrienus)[1]			1.7		2.4		2.1		10.1	
7	Camel, bactrian (C. bactrienus)[1,4,5]				1.2-2.1		1.7-3.8		11.1-13.1		
8	Camel, dromedary (C. dromedarius)[1,4]				0.2-1.7	15.7	12.3-19.1	3.8?		14	
9								17.6-18.1?			
10	Cat, domestic (Felis catus)[1]						3.9-8.1				0.57-1.9
11	Cat, domestic (F. catus)[1,2,6]						4-4.9	0.6-0.9			
12	Cat, domestic (F. catus)[1,2,7]						3.9-7.9	2.5-3.9			
13	Cat, domestic (F. catus)[1,2,8]						3.5-5.5	0.49-1.07			
14	Cat, domestic (F. catus)[1,2,9]						5.7-11.1	1.49-2.46			
15	Dog, domestic (Canis familiaris)[1,2]					3.5	3.5-28			0.8	
16								0.9-10			
17	Hyena (Hyaena (spp.))[1,2]	1.75		0.95		4.0		0.29		0.59	
18								0.88			
19	Leopard (Panthera pardus)[1,2]	0.52		0.86		3.2		0.44		0.88	
20								1.32			
21	Llama (Llama glama)[1,2]	21.4		1.4	1.3-1.4	2.0	1.8-2.2	2.2		8.3	
22								9.1-11.7			
23	Seal, harbor (Phoca vitulina)[1,11]						8-16		6-8		
24	Seal, harbor (P. vitulina)[1,10,11]						9.9-16.8	12.9-31			
25	Seal, harbor (P. vitulina)[1,10,12]						2-7.5	9.1-31			
26	Tiger (Panthera tigris)[1,2]	1.3		0.95		3.3		0.43		1.29	
27								1.72			
28	Weasel (Mustela (spp.))[1,2]	0.48		0.89		2.6		1.37		0.3	
29								1.67			
30	Whale, finner (Balaenoptera physalus)[1,10]						1-1.5			Trace	
31								0.3-3.8			
32	Whale, sei (B. borealis)[1,10]					5.7	3.2-9.4	0.8;0.5-1.2			

	VERTEBRATA (cont'd)										
	Aves										
33	Duck (Anas (spp.))[1,13]					3.2					
34	Fowl, domestic (Gallus domesticus)[1,2]			6		1.5	1.5-17.3			8	
35	Fowl, domestic (G. domesticus)[1,2]						14.9-19.5	7.4-9.1			
36	Fowl, domestic (G. domesticus)[1,2]						3-4				
37	Goose (Anser (spp.))[1,13]					13.5					
38	Swan (Cygnus (spp.))[1,13]					15.8					
	Reptilia										
39	Alligator (Alligator (spp.))[1]						37-76				
40	Alligator, American (A. (spp.))[1,14]						66-81				
41	Lizard (Chalcides ocellatus)[1,2]	2.7									
42	Lizard (Scincus officianalis)[1,2]	1.6									
43	Lizard, European (Lacerta (spp.))										
44	Lizard, horned (Phrynosoma cornutum)[1,4]					0.6?				Trace	
45	Python (Python (spp.))[1,2]			2.3		8.7					
46	Snake (Eryx thebaicus)[1,2]	0		1.1		5.7		0.23			
47	Snake (Trepidonotus (spp.))					Trace					
48	Snake (Zamenis diadema)[1,2]	0		4.5		4.3					
49	Tortoise (Chelons mydas)[1]					16.1		2.6	0.9		
50	Tortoise (C. mydas)[1,15]						29-51	5.2-11.5			
51	Tortoise (Emys orbicularis)[1,13]		0.3-0.9	19.7	15.8-21.9	14.4	10.6-18.8				
52	Tortoise (Kinixys erosa)[1,2]	0.4		13.7	12.7-14.7	6.1	5.7-6.5				
53	Tortoise (K. youngi)[1,15]		0.3-1.3	15.2	7.7-22	6	2.9-12.5				
54	Tortoise (Kinosternon subrubrum)[1,15]	1.1		10		24					
55	Tortoise (Pelusios derbianus)[1,15]	1		20.6		18.5					
56	Tortoise (Testudo elegans)[1,4]		1-1.2	13.1	10.6-15.5	6.2	5.9-6.5				
57	Tortoise (T. graeca)										
58	Tortoise (T. graeca)[1,2]		1.4-1.9	6.6	4.5-8.6	4.1	4.0-4.1				
59	Tortoise (T. denticulata)[1,2]		6.7-8.6	15.6	9.4-22.2	6	3.9-8.7				
60	Tortoise, painted western (Chrysemys picta)[1,15]			11.5?	3.8-8.2?	15.3	9.8-20.7	5.5			
61	Turtle ((Genus) (spp.))[1,15]						14.5-17.7		3.5-11.3		
	Amphibia										
62	Frog (Rana catesbiana)[1]						3-38				
63	Frog (R. virescens)[1,14,16]					5.1	1.2-7.4				
64	Frog (R. (spp.))[1,14,17]					20.9					
65	Frog (R. (spp.))[1,14,18]					12.2					
	Pisces										
66	Bowfin (Amia calva)[1,11,14]			8.7		32		20.9			
67	Carp (Cyprinus (spp.))[1,19]			2.6			75-77				

/1/ Urine analyzed. /2/ Terrestrial habitat. /3/ Mountain habitat. /4/ Dry terrestrial. /5/ Pregnant specimen. /6/ Purine-rich diet. /7/ Purine-free diet. /8/ Protein-rich diet. /9/ Low protein diet. /10/ Marine form. /11/ Fasting. /12/ Feeding. /13/ Semi-aquatic. /14/ Fresh-water. /15/ Aquatic. /16/ Hibernating specimen. /17/ Kept at 11°C. /18/ Kept at 22°C. /19/ Analysis made from a small portion of the surrounding medium.

112. PARTITION OF EXCRETED NITROGEN: ANIMALS (Section I)

(See p. 202ff for columns L-T of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted.

	Species	Allantoin-N		Amino Acid-N		Ammonia-N		Creatine-N		Creatinine-N	
		Value	Range	Value	Range	Value	Range	Value	Range	Value	Range
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	VERTEBRATA (concluded)										
	Pisces (concluded)										
68	Carp (Cyprinus carpio)			2.6			60-78				
69	Carp (C. carpio)[1,11,14]						3.3-21.6		18.2-68		
70	Catfish (Ictalurus furcatus)[1,14]			20		27			7.9		
71	Cod (Gadus collaris)[10,11,20]				14.8-21.4				53-56		
72	Dogfish (Mustelus (spp.))					7.3					
73	Eel (Anguilla cryspa)[1,11,14]						11.7-23.4		21.8-31		
74	Flounder (Pseudopleuronectes americanus)[1,10]			8.9	8.2-9.7	2.2	1.8-2.6			20.5	
75									15.0-26		
76	Gar, longnosed (Lepidosteus osseus)[1,14]			4.1		34			4.1		
77	Goldfish (Carassius auratus)[21]					73					
78	Goldfish (C. auratus)[1,11,14]						6.2-15.7		11.9-19.2		
79	Goosefish; Anglerfish (Lophius piscatorius)[1,10]			8.4	5.3-15.4	0.6	0.3-1.3			2.6	
80									24.5-64		
81	Goosefish; Anglerfish (L. piscatorius)[10,22]										
82	Goosefish; Anglerfish (L. piscatorius)[10,20]				14.9-34		2-5.4		21-47		
83	Goosefish; Anglerfish (L. piscatorius)[1,10]			5		2					
84	Lungfish (Protopterus (spp.))[1,23]					41		0.54		6.28	
85	Lungfish (Protopterus aethiopicus)[1,14]					61			10.2		
86	Minnow (Hyborhynchus (spp.))					75					
87	Puffer (Spheroides maculatus)[10,11,20]			20.6			5.1-6.2		12.4-59		
88	Red grouper (Epinephalus morio)[1,11,14]			6.4					17.1		
89	Sculpin (Myoxocephalus octodecimspinosus)[1,10]			4.2	4-4.4	1.6	1.3-2			23	
90									22.4-25		
91	Seahorse (Hippocampus (spp.))[10,19]			13.8		63					
92	Sheepshead (Archosargus probatocephalus)[1,11,14]				15-19.9		8.4-9.6		15.1-15.5		
93	Sole (Solea (spp.))[10,19]					53					
94	Torpedo; Numbfish (Torpedo (spp.))[10,19]			0.8		3.8					
95	Torpedo; Numbfish (T. (spp.))[1,19]			1.7		1.7					
	ARTHROPODA										
	Insecta										
96	Blowfly (larva) (Calliphora (spp.))[2,24]					Trace					
97	Blowfly (larva) (Lucilia (spp.))[2,24]					Trace[25]		Trace			

	ARTHROPODA (cont'd)										
	Insecta (concluded)										
98	Cone-nose bug (Rhodnius prolixus)[1,2]			0		0		Trace			
99	Grasshopper (larva) (Melanopus (spp.))[24]			17.7		3.3				0	
100	Grasshopper (M. bivittatus)[24]				6.2-8		1.6-1.7				
101	Moth (Antheraea pernyi)[2,24]	0				22.4					
102	Moth (A. pernyi)[2,26]	0				6.2					
103	Moth (A. pernyi)[2,27]	0				2.6					
104	Moth (larva) (A. pernyi)					4.4					
105	Moth (A. pernyi)[28]					5.1					
106	Moth (A. pernyi)[29]					4.7					
107	Moth (A. pernyi)[2,27]					4.1					
108	Moth (A. pernyi)[31]			9.5		1.8					
109	Moth (A. pernyi)[2,31]			3.1		9.6					
110	Moth (Saturnia pyri)[2,31]			2.7		0.3					
111	Moth (Sphinx ligustri)[31]			9.3		3.8					
112	Moth (S. ligustri)[2,31]			2.9		1.2					
113	Moth, case-making cloth (Tinea pellionella)			10		10.2					
114	Moth, clothes (Tinialla crinella)					20.7					
115	Moth, webbing clothes (Tineola biselliella)[2,24]					12.7					
116	Silkworm (Bombyx mori)										
	Crustacea										
117	Amphipod (Gammarus locusta)[32,33]				5-8		74-91				
118	Amphipod (G. pulex)[14,32]				0-10		58-82				
119	Amphipod (G. zaddachi)[32,33]				0-6		73-88				
120	Amphipod (Marinogammarus marinus)[32,33]				4-8		68-87				
121	Amphipod (M. pirloti)[32,33]				0-9		79-96				
122	Amphipod (Orchestia (spp.))[10,32,34]				6-26		51-91				
123	Crab (Cancer pagurus)[1,10]			20		43					
124	Crab (Eriocheir sinensis)[10,19]					75?	27-97				
125	Crab, shore (Carcinus maenas)[10,19]			8.7	3.7-8.7	68	67-69				
126	Crab, shore (C. maenas)			7.7		71.4					
127	Crab, spider (Maja squinado)[1,10]			28	16.4-28	12.4	4-12.4				
128	Crayfish (Astacus fluviatilis)[14,19]			10.1	5.9-12.5	60	53-65				
129	Crayfish (A. fluviatilis)[11,14,19]			5.9		62					
130	Crayfish (A. fluviatilis)[12,14,19]			11.8		65					
131	Isopod (Armadillidium vulgare)[14,32]				0-11		51-59				
132	Isopod (Asellus aquaticus)[14,32]				3-21		55-71				
133	Isopod (Ligia oceanica)[10,32,34]				0-13		58-99				
134	Isopod (Oniscus asellus)[2,32]				0-12		44-50				
135	Isopod (Porcellio laevis)[2,32]				0-2		56-58				

/1/ Urine analyzed. /2/ Terrestrial habitat. /10/ Marine form. /11/ Fasting. /14/ Fresh-water. /19/ Analysis made from a small portion of the surrounding medium /20/ Urine for analysis within 24 hours post-mortem. /21/ Gills and urine analyzed. /22/ Ammonia removed by distillation from urine analyzed. /23/ Active specimen. /24/ Feces analyzed. /25/ This constituent found if meat is fed. /26/ Analysis from extract of malphigian tubules. /27/ Exuvial fluid analyzed. /28/ Over winter pupa. /29/ Early pupa. /30/ 4 week pupa. /31/ Meconium analyzed. /32/ Medium and solid excreta analyzed. /33/ Marine-littoral form. /34/ Semi-terrestrial form.

112. PARTITION OF EXCRETED NITROGEN: ANIMALS (Section I, Concluded)

(See p. 202ff for columns L-T of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted.

	Species	Allantoin-N		Amino Acid-N		Ammonia-N		Creatine-N		Creatinine-N	
		Value	Range	Value	Range	Value	Range	Value	Range	Value	Range
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
	MOLLUSCA										
	Cephalopoda										
136	Cuttlefish (Sepia officinalis)[1,10]			7.8	7.2-8.4	67	64-70				
137	Octopus (Octopus vulgaris)[1,10]			12.5			33-42?				
138	Octopus (O. vulgaris)[10,19]			20		50					
	Gastropoda										
139	Periwinkle (Littorina littorea)[10,19,35]			7		12.6					
140	Periwinkle (L. littorea)[10,19,36]			10		1.9					
141	Sea-hare (Aplysia (spp.))[10,19]			13.0		34	30-37				
142	Sea-hare (A. limacina)[10,19,37]			13.0		37					
143	Sea-hare (A. limacina)[10,37,38]			31		14					
144	Sea-hare (A. limacina)[10,19,39]					30					
145	Sea-hare (A. limacina)[10,38,39]			32		8.2					
146	Slug (Arion empiricorum)[2,40]			18.0	11.3-18.0	9.8	7.1-9.8				
147	Slug (Limax agrestis)[2,40]				0.5-2.9		4.2-5.0				
148	Snail, edible (Helix pomatia)[2,11,40]			7.0		22.2					
149	Snail, edible (H. pomatia)[2,12,40]			5.2		13.7					
150	Snail, edible (H. pomatia)[2,11,40]				3.5-10		12.5-37				
151	Snail, edible (H. pomatia)[2,12,40]				3.2-6.4		7.1-26				
152	Snail, fresh-water (Paludina vivipara)[14,19,35,40]			27		4.4					
153	Snail, fresh-water (P. vivipara)[14,19,36,41]				29	13 1					
154	Snail, pond (Limnaea stagnalis)					13.8					
155	Snail, pond (L. stagnalis)[14,19,36]			28		9.0					
	Pelecypoda										
156	Clam (Mya arenaria)[10,19]			18		21.5					
157	Clam (M. arenaria)[10,38]			30		4.8					
158	Clam, fresh-water (Anodonta cygnea)[41]					60					
159	Clam, fresh-water (A. cygnea)[14,42]					6,26	4.7-8				
160	Clam, fresh-water (A. cygnea)[14,43]					40	16-61				
161	Mussel (Mytilus edulis)[10,19]			24.4	17.1-36	7.4	Trace-11.4				
162	Mussel, fresh-water (Unio pictorum)[14,19,35]					24.8					
163	Mussel, fresh-water (U. pictorum)[14,19,36]			29		44					
164	Oyster (Gryphoea angulata)[10,38]			13.2		7.2					

	ANNELIDA										
165	Earthworm (Lumbricola agricola)[2,11,40]			20		46					
166	Earthworm (L. agricola)[2,12,40]			12.2		20.4					
167	Earthworm (Lumbricus terrestris)[2,12,44]				16-20	47	47-48				
168	Earthworm (L. terrestris)[2,12,24]					<10					
169	Earthworm (L. terrestris)[2,11,44]				12.2-15		20.4-47				
170	Earthworm (L. terrestris)[2,11,41]						66-91				
171	Earthworm, Indian (Pheretima posthuma)[1,2]			0.6		45				7.8	
172	Earthworm, Indian (P. posthuma)[2,45]					62					
173	Earthworm, Indian (P. posthuma)[2,40]					75					
174	Leech (Hirudo medicinalis)[11,14,19]			4.5		78					
175	Leech (H. medicinalis)[12,14,19]			1.9		74.5					
176	Leech (H. medicinalis)[14,19,42]					76	70-81				
177	Leech (H. medicinalis)[14,19,43]					45	34-60				
178	Leech (H. officianalis)[11,14,40]			3.5	3.5-5.5	79					
179	Leech (H. officianalis)[12,14,40]			3.3	0.6-3.3	71					
180	Sea-mouse (Aphrodite aculeata)[1]					80					
181	Sea-mouse (A. aculeata)[10,45]			35		13.3					
	Sipunculoidea										
182	Worm, marine (Sipunculus nudus)[10,19]			16.6		50					
	ECHINODERMATA										
183	Sea-cucumber (Holothuria tubulosa)[10,19]			18	18-18.7	39	39-41				
184	Sea-urchin (Paracentrotus lividus)[10,19]			28	25-29	28	26-30				
185	Starfish (Asteriae rubens)[10,19]			24	17.3-28	39	23.7-48				
	COELENTERATA										
186	Sea-anemone (Actiniaria (spp.))[19]					53					
	PROTOZOA										
187	Ciliate (Colpidium campylum[14,19]					Present					
188	Ciliate (Didinium (spp.))[14,19]					Present					
189	Ciliate (Glaucoma (spp.))[14,19]			Present[46]		Present					
190	Ciliate (Paramecium (spp.))[19]					91[47]					
191	Ciliate (P. (spp.))[14,19]										
192	Ciliate (P. (spp.))[11,14,19]					91					
193	Ciliate (P. (spp.))[14,19,48]					55[49]					
194	Ciliate (P. (spp.))[14,19,50]					76[51]					
195	Ciliate (P. caudatum)[14,19]					Present					
196	Ciliate (Spirostomum ambiguum)[19]					Present[52]					
197	Ciliate (S. ambiguum)[14,19]										
198	Flagellate (Bodo (spp.))[14,19]					Present					

/1/ Urine analyzed. /2/ Terrestrial habitat. /10/ Marine form. /11/ Fasting. /12/ Feeding. /14/ Fresh-water. /19/ Analysis made from a small portion of the surrounding medium. /24/ Feces analyzed. /35/ Summer. /36/ Winter. /37/ Small specimens. /38/ Mantle cavity fluid. /39/ Large specimens. /40/ Washings analyzed. /41/ Total excreta analyzed. /42/ Distilled water medium analyzed. /43/ Acid medium analyzed. /44/ Analyzed from washings collected over 8 day period. /45/ Coelomic fluid analyzed. /46/ Amides. /47/ With no substrate. With glycine substrate 55% of N.P.N. with starch substrate, 0. /48/ Fed glycine. /49/ Non-amino nitrogen. /50/ Fed fibrin. /51/ Total nitrogen of medium. /52/ Zero at low O_2 (hypoxia).

112. PARTITION OF EXCRETED NITROGEN: ANIMALS (Section II)

(See p. 196ff for columns B-K of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted.

	Species	Purine-N (Minus Uric Acid-N)		Urea-N		Uric Acid-N		Other Specified-N	Unidentified-N	
		Value	Range	Value	Range	Value	Range		Value	Range
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
	VERTEBRATA									
	Mammalia									
1	Man (Homo sapiens)[1,2]			87	85-90	1.4	0.5-1.5		4	2-6.4
2										
3	Alpaca (Auchenia vicunna)[1,3]			60		0.3			28	
4	Bat (Xantharpyia (spp.))[1,2]			63		0.87			20.3	
5										
6	Camel, bactrian (Camelus bactrianus)[1]			68		1.3			14.8	
7	Camel, bactrian (Camelus bactrianus)[1,4,5]				65-69		0.8-1.8			14-16.1
8	Camel, dromedary (Camelus dromedarius)[1,4]			44	33-56	0.3			16.2	13-20
9										
10	Cat, domestic (Felia cetus)[1]				72-84		0.02-0.22			
11	Cat, domestic (F. catus)[1,2,6]				68-90	0.1				
12	Cat, domestic (F. catus)[1,2,7]				80-86	0.01				
13	Cat, domestic (F. catus)[1,2,8]				78-89		0.1-0.35			
14	Cat, domestic (F. catus)[1,2,9]				58-80		0-0.09			
15	Dog, domestic (Canis familiaris)[1,2]			91	46-92				5	1.4-22
16										
17	Hyena (Hyaena (spp.))[1,2]	0.23		89		0.06			2.8	
18										
19	Leopard (Panthera pardus)[1,2]	0.25		87		0.06				
20										
21	Llama (Llama glama)[1,2]			64	61-68	0.8				
22										
23	Seal, harbor (Phoca vitulina)[1,11]				65-80		6-11			
24	Seal, harbor (P. vitulina)[1,10,11]				52-73					
25	Seal, harbor (P. vitulina)[1,10,12]				61-90					
26	Tiger (Panthera tigris)[1,2]	0.18		89		0.06			3.4	
27										
28	Weasel (Mustela (app.))[1,2]	0.58		91		0.16			2.6	
29										
30	Whale, finner (Balaenoptera physalus)[1,10]				90-95?	3	1.6-4.4			2.7-3.1

	VERTEBRATA (cont'd)									
	Mammalia (concluded)									
31										
32	Whale, sei (Balaenoptera borealis)[1,10]			88	83-93	1.8	0.6-4.25		3.9	2.3-6.1
	Aves									
33	Duck (Anas (spp.))[1,13]			4.2		72			20.7	
34	Fowl, domestic (Gallus domesticus)[1,2]	8		0.9	0.9-10.4	70	63-87		28	
35	Fowl, domestic (G. domesticus)[1,2]				9.2-11.5		59-70			0.3-2.9
36	Fowl, domestic (G. domesticus)[1,2]			10		87			0	
37	Goose (Anser (spp.))[1,13]					80			6.5	
38	Swan (Cygnus (spp.))[1,13]			2.6		69			13.9	
	Reptilia									
39	Alligator (Alligator (spp.))[1]				4-24		11-39			
40	Alligator, American (Alligator (spp.))[1,14]				1.3-17		7-19.8			0.2-23
41	Lizard (Chalcides ocellatus)[1,2]			0		93				
42	Lizard (Scincus officianalis)[1,2]					94				
43	Lizard, European (Lacerta (spp.))					91				
44	Lizard, horned (Phrynosoma cornutum)[1,4]			0		98?			Trace	
45	Python (Python (spp.))[1,2]					89				
46	Snake (Eryx thebaicus)[1,2]	0.3		0		63		0.95[53]	29.1	
47	Snake (Trepidonotus (spp.))			Trace		80				
48	Snake (Zamenis diadema)[1,2]	2.0		2.0		67		2.7[53]	9	
49	Tortoise (Chelone mydas)[1]			38		16.5			37	
50	Tortoise (C. mydas)[1,15]				0-12		1.4-6.3	8-23[53]		2.4-22
51	Tortoise (Emys orbicularis)[1,13]			47	26-69	2.5	1.4-4	0.5-1.2[54]	14.8	
52	Tortoise (Kinixys erosa)[1,2]			61	50-72	4.2	3.5-5	0.45[54]	15.2	
53	Tortoise (K. youngi)[1,2]			44	30-73	5.5	3.4-8.7	0.3-3.8[54]	26	
54	Tortoise (Kinosternon subrubrum)[1,15]			22.9		0.7		1[54]	40	
55	Tortoise (Pelusios derbianus)[1,15]			24.4		4.5		3.8[54]	27	
56	Tortoise (Testudo elegans)[1,4]			8.5	7.8-9.1	56	54-58	0.9-5.1[54]	12	
57	Tortoise (Testudo graeca)			90		Trace				
58	Tortoise (T. graeca)[1,2]			22.3	15.3-29.3	52	49-55	8.7-10.1[54]	4	
59	Tortoise (T. denticulata)[1,2]			29	27-31	6.7	4.9-7.7	1.7-5[54]	32	
60	Tortoise, painted western (Chrysemys picta)[1,15]			39	24.1-48	18.8	7.4-28		18.6	16.6-41
61	Turtle ((Genus) (spp.))[1,15]				31-45		14-19.1			
	Amphibia									
62	Frog (Rana catesbiana)[1]				62-88		Trace-0.4		7.25	

/1/ Urine analyzed. /2/ Terrestrial habitat. /3/ Mountain habitat. /4/ Dry terrestrial. /5/ Pregnant specimen. /6/ Purine-rich diet. /7/ Purine-free diet. /8/ Protein-rich diet. /9/ Low protein diet. /10/ Marine form. /11/ Fasting. /12/ Feeding. /13/ Semi-aquatic. /14/ Fresh-water. /15/ Aquatic. /53/ Hippuric acid nitrogen. /54/ Guanine and xanthine nitrogen.

112. PARTITION OF EXCRETED NITROGEN: ANIMALS (Section II)

(See p. 196ff for columns B-K of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted.

	Species	Purine-N (Minus Uric Acid-N)		Urea-N		Uric Acid-N		Other Specified-N	Unidentified-N	
		Value	Range	Value	Range	Value	Range		Value	Range
		g/100 g	g/100g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100g
	(A)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
	VERTEBRATA (concluded)									
	Amphibia (concluded)									
63	Frog (Rana virescens)[1,14,16]			87	82-91	0.3	0.2-0.4			1.9-13.7
64	Frog (R. (spp.))[1,14,17]			68					10.9	
65	Frog (R. (spp.))[1,14,18]			78					10.2	
	Pisces									
66	Bowfin (Amia calva)[1,11,14]			15.6		22.6				
67	Carp (Cyprinus (spp.))[14,19]				12.5-14.5					5.5-12.5
68	Carp (C. carpio)				6-15	0.2			22	
69	Carp (C. carpio)[1,11,14]			3.7		0.6				32-79
70	Catfish (Ictalurus furcatus)[1,14]			24.6					16.9	
71	Cod (Gadus collaria)[10,11,20]				6.5-11.2		1.7-2.4		15.2-19	
72	Dogfish (Mustelus (spp.))			81		0.2				
73	Eel (Anguilla cryspa)[1,11,14]				10.7-23.4		1.3-5.4			17.1-56
74	Flounder (Pseudopleuronectes americanus)[1,10]			17.3	13.5-21.2	1.2	1.2-1.3	0.4-1[55]	50	48.3-51.1
75										
76	Gar, longnosed (Lepidosteus osseus)[1,14]			5.0					53	
77	Goldfish (Carassius auratus)[21]			9.9					16.8	
78	Goldfish (C. auratus)[1,11,14]			Trace		1.1				71-75
79	Goosefish; Anglerfish (Lophius piscatorius)[1,10]			0.9	0.1-2.7	0.2	0.2-0.4	37[55]	5.2?	28-63?
80										
81	Goosefish; Anglerfish (L. piscatorius)[10,22]							80[55]	20	
82	Goosefish; Anglerfish (L. piscatorius)[10,20]				1.5-3.6		0.7-1.8			20-51
83	Goosefish; Anglerfish (L. piscatorius)[1,10]			28					65	
84	Lungfish (Protopterus (spp.))[1,23]			18.5		0.8				
85	Lungfish (P. aethiopicus)[1,14]			28		1.2				
86	Minnow (Hyborhynchus (spp.))			12.5						
87	Puffer (Spheroides maculatus)[10,11,20]				1.8-19.1		0.8-1.2			9.1-85
88	Red grouper (Epinephalus morio)[1,11,14]			31					46	
89	Sculpin (Myoxocephalus octodecimspinosus)[1,10]			14.6	14.1-15.3	0.7		23[55]	55	54-56
90										
91	Seahorse (Hippocampus (spp.))[10,19]			8.9					14.2	

	VERTEBRATA (concluded)									
	Pices (concluded)									
92	Sheepshead (Archosargus probatocephalus)[1,11,14]				22.9-23		6.4-8.4			25-26
93	Sole (Solea (spp.))[10,19]			16.6					30.4	
94	Torpedo; Numbfish (Torpedo (spp.))[10,19]			91					4.0	
95	Torepdo; Nubmfish (Torpedo (spp.))[1,19]			85					11.3	
	ARTHROPODA									
	Insecta									
96	Blowfly (larva) (Calliphora (spp.))[2,24]			Trace		Trace				
97	Blowfly (larva) (Lucilia (spp.))[2,24]			Trace[25]		Trace[56]				
98	Cone-nose bug (Rhodnius prolixus)[1,2]			Trace		90-92				8-10
99	Grasshopper (Melanopus (spp.))[24]			8.7		70				
100	Grasshopper (M. bivittatus)[2,24]				6.6-8.4		82-86			
101	Moth (Antheres pernyi)[2,24]			0		73			5	
102	Moth (A. pernyi)[2,26]			9.4		79			5	
103	Moth (A. pernyi)[2,27]			0		76			21.3	
104	Moth (larva) (A. pernyi)			6.7		89				
105	Moth (A. pernyi)[28]			7.7		85				
106	Moth (A. pernyi)[29]			7.4		86				
107	Moth (A. pernyi)[30]			8		85				
108	Moth (A. pernyi)[31]			Trace		80				
109	Moth (A. pernyi)[2,31]			Trace		26				
110	Moth (Saturnia pyri)[2,31]			Trace		23				
111	Moth (Sphinx ligustri)[31]			Trace		81				
112	Moth (S. ligustri)[2,31]			Trace		25				
113	Moth, case-making clothes (Tinea pellionella)			17.6		47.3				
114	Moth, clothes (Tinella crinella)			1.8		77.5				
115	Moth, webbing clothes (Tineola biselliella)[2,24]			1.5		47			39	
116	Silkworm (Bombyx mori)			0		86				
	Crustacee									
117	Amphipod (Gammarus locusta)[32,33]		2-4		Trace-3					3-22
118	Amphipod (G. pulex)[14,32]		7-20		5-15					2-16
119	Amphipod (G. zaddachi)[32,33]		1-4		0-4					2-17
120	Amphipod (Marinogammarus marinus)[32,33]		4-18							2-18

/1/ Urine analyzed. /2/ Terrestrial habitat. /10/ Marine form. /11/ Fasting. /14/ Fresh-water. /16/ Hibernating specimen. /17/ Kept at 11°C. /18/ Kept at 22°C. /19/ Analysis made from a small portion of the surrounding medium. /20/ Urine for analysis obtained within 24 hours post-mortem. /21/ Gills and urine analyzed. /22/ Ammonia removed by distillation from urine analyzed. /23/ Active specimen. /24/ Feces analyzed. /25/ This constituent found if meat is fed. /26/ Analysis from extract of malphigian tubules. /27/ Exuvial fluid analyzed. /28/ Over winter pupa. /29/ Early pupa. /30/ 4 week pupa. /31/ Meconium analyzed. /32/ Medium and solid excreta analyzed. /33/ Marine-littoral form. /55/ Trimethylamine oxide nitrogen. /56/ Allantoic acid excreted, uric acid stored.

112. PARTITION OF EXCRETED NITROGEN: ANIMALS (Section II)

(See p. 196ff for columns B-K of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted.

	Species	Purine-N (Minus Uric Acid-N)		Urea-N		Uric Acid-N		Other Specified-N	Unidentified-N	
		Value	Range	Value	Range	Value	Range		Value	Range
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
	ARTHROPODA (concluded)									
	Crustacea (concluded)									
121	Amphipod (Marinogammarus pirloti)[32,33]		1-3							4-18
122	Amphipod (Orchestia (spp.))[10,32,34]		6-11		0-3					7-17
123	Crab (Cancer pagurus)[1,10]	10		12.9		2.8			11.5	4-11.5
124	Crab (Eriocheir sinensis)[10,19]			5		Trace[57]				
125	Crab, shore (Carcinus maenas)[10,19]	3.2	2.5-3.2	3	3-4.2	0.7	0.2-1.2			17.3-20.1
126	Crab, shore (C. maenas)	3.9		2.2		0.6				
127	Crab, spider (Maja squinado)[1,10]	6.6	0-7.4	2.1	2.1-8.5	1.3	1.3-4.7			51-71
128	Crayfish (Astacus fluviatilis)[14,19]	4.4	3.2-6.4	11.2	10.2-11.8	0.8	0.3-1.2		14.7	
129	Crayfish (A. fluviatilis)[11,14,19]	6.4		11.7		1.2			13.1	
130	Crayfish (A. fluviatilis)[11,14,19]	3.7		11.8		0.8			7.4	
131	Isopod (Armadillidium vulgare)[14,32]				0-2		4-15			23-27
132	Isopod (Asellus aquaticus)[14,32]		0-13				1-9			14-37
133	Isopod (Ligia oceanica)[10,32,34]		0-6							1-24
134	Isopod (Oniscus asellus)[2,32]		14-38				4-5			8-25
135	Isopod (Porcellio laevis)[2,32]		10-20				2-6			18-28
	MOLLUSCA									
	Cephalopoda									
136	Cuttlefish (Sepia officinalis)[1,10]	4.9	3.2-4.9	1.7	1.4-2.1	2.1	2.1-2.2			18.6-20.2
137	Octopus (Octopus vulgaris)[1,10]	25		15.0?		1.4?			29	
138	Octopus (O. vulgaris)[10,19]			15		2			14	
	Gastropoda									
139	Periwinkle (Littorina littorea)[10,19,35]	29		140		0.8			11	
140	Periwinkle (L. littorea)[10,19,36]	16		61		1.1			10.4	
141	Sea-hare (Aplysia (spp.))[10,19]		15-16.7	8.7	7.4-10	4.6	Trace-9.2			24.1-45
142	Sea-hare (A. limacina)[10,19,37]	18.5		7.4		9.2			14.9	
143	Sea-hare (A. limacina)[10,37,38]	3.9		3.9		2.3			45	
144	Sea-hare (A. limacina)[10,37,38]	15		10					45	
145	Sea-hare (A. limacina)[10,38,39]	4.1		2.3		3.2			50.4	
146	Slug (Arion empiricorum)[2,40]	16.6	3-20.2	2.8		3.3	1.4-10.3			52-80

	MOLLUSCA (concluded)									
	Gastropoda (concluded)									
147	Slug (Limax agrestis)[2,40]		5.1-16.6		61-80		3-6.9			6.9-7.2
148	Snail, edible (Helix pomatia)[2,11,40]	19		16.8		7[57]			35	
149	Snail, edible (H. pomatia)[2,12,40]	16.5		22		10.7[57]			43	
150	Snail, edible (H. pomatia)[2,11,40]		10-29.1		8-25.8		2.4-10			
151	Snail, edible (H. pomatia)[2,12,40]		5.1-21.4		10-35		4-20			
152	Snail, fresh-water (Paludina vivipara)[14,19,35,40]	30		8.1		6.6			24	3-24
153	Snail, fresh-water (P. vivipara)[14,19,36]	31		13		10.8			2.8	
154	Snail, pond (Limnaea stagnalis)[14,19,35]			42.3		5			39	
155	Snail, pond (L. stagnalis)[14,19,36]	27				4			32	
	Pelecypoda									
156	Clam (Mya arenaria)[10,19]	5		4.5		Trace			51	
157	Clam (M. arenaria)[10,38]			5		1.2			41	
158	Clam, fresh-water (Anodonta cygnea)[41]									
159	Clam, fresh-water (A. cygnea)[14,42]									
160	Clam, fresh-water (A. cygnea)[14,43]									
161	Mussel (Mytilus edulis)[10,19]	9.7	Trace-16	Trace		0			58.3	37-79.4
162	Mussel, fresh-water (Unio pictorum)[14,19,35]								75	
163	Mussel, fresh-water (U. pictorum)[14,19,36]	20							6.1	
164	Oyster (Gryphoea angulata)[10,38]			3.2		1.6			75	
	ANNELIDA									
165	Earthworm (Lumbricola agricola)[2,11,40]	6		12					16	
166	Earthworm (L. agricola)[2,12,40]			38					29	
167	Earthworm (Lumbricus terrestris)[2,12,44]		4.6-6		6-12	0				15.4-25
168	Earthworm (L. terrestris)[2,12,24]				82-86					
169	Earthworm (L. terrestris)[2,11,44]	17.5			10-38	0			>10	10.5-29
170	Earthworm (L. terrestris)[2,11,41]			<10						
171	Earthworm, Indian (Pheretima posthuma)[1,2]			55		0				
172	Earthworm, Indian (P. posthuma)[2,45]			38						
173	Earthworm, Indian (P. posthuma)[2,40]			25						
174	Leech (Hirudo medicinalis)[11,14,19]	4.3		3.8		0			9.1	
175	Leech (H. medicinalis)[12,14,19]	2.9		7		Trace			13.7	
176	Leach (H. medicinalis)[14,19,42]									
177	Leech (H. medicinalis)[14,19,43]									

/1/ Urine analyzed. /2/ Terrestrial habitat. /10/ Marine form. /11/ Fasting. /12/ Feeding. /14/ Fresh-water. /19/ Analysis made from a small portion of the surrounding medium. /24/ Feces analyzed. /32/ Medium and solid excreta analyzed. /33/ Marine-littoral form. /34/ Semi-terrestrial form. /35/ Summer. /36/ Winter. /37/ Small specimens. /38/ Mantle cavity fluid. /39/ Large specimens. /40/ Washings analyzed. /41/ Total excreta analyzed. /42/ Distilled water medium analyzed. /43/ Acid medium analyzed. /44/ Analyzed from washings collected over 8 day period. /45/ Coelomic fluid analyzed. /57/ Collection method probably did not insure complete recovery of uric acid.

112. PARTITION OF EXCRETION NITROGEN: ANIMALS (Section II, Concluded)

(See p. 196ff for columns B-K of this table)

Values are grams of nitrogen in the combination specified in the column headings, per 100 grams of total nitrogen excreted.

	Species	Purine-N (Minus Uric Acid-N)		Urea-N		Uric Acid-N		Other Specified-N	Unidentified-N	
		Value	Range	Value	Range	Value	Range		Value	Range
		g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	(A)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)
	ANNELIDA (concluded)									
178	Leech (Hirudo officianalis)[11,14,40]	5.2	3.5-5.2	3.5	3.5-4.2	0			8.7	
179	Leech (H. officianalis)[12,14,40]	3.8	2-3.8	10	4-10	0			11.8	
180	Sea-mouse (Aphrodite aculeata)[1]			0.2		0.8				
181	Sea-mouse (A. aculeata)[10,45]			11.1		1.1			39	
	Sipunculoidea									
182	Worm, marine (Sipunculus nudus)[10,19]	4.1		9.7		0			19.4	
	ECHINODERMATA									
183	Sea-cucumber (Holothuria tubulosa)[10,19]	12	12-12.5	6	6-6.25	0			25	18.75-25
184	Sea-urchin (Paracentrotus lividus)[10,19]	11		7.5	5-10	1				20.2-24.3
185	Starfish (Asterias rubens)[10,19]		3.6-10	11.7	8.0-18.7	Trace				16-26
	COELENTERATA									
186	Sea-anemone (Actiniaria (spp.))[19]			42						
	PROTOZOA									
187	Ciliate (Colpidium campylum)[14,19]			Present		0				
188	Ciliate (Didinium (spp.))[14,19]			0						
189	Ciliate (Glaucoma (spp.))[14,19]			0		0				
190	Ciliate (Paramecium (spp.))[19]			0						
191	Ciliate (P. (spp.))[14,19]			Present[58]						
192	Ciliate (P. (spp.))[11,14,19]								9	
193	Ciliate (P. (spp.))[14,19,48]									
194	Ciliate (P. (spp.))[14,19,50]									
195	Ciliate (P. caudatum)[14,19]									
196	Ciliate (Spirostomum ambiguum)[19]			Present						
197	Ciliate (S. ambiguum)[19]			Trace[58]						
198	Flagellate (Bodo (spp.))[14,19]			0						

/1/ Urine analyzed. /10/ Marine form. /11/ Fasting. /12/ Feeding. /14/ Fresh-water. /19/ Analysis made from a small portion of the surrounding medium. /40/ Washings analyzed. /45/ Coelomic fluid analyzed. /48/ Fed glycine. /50/ Fed fibrin. /58/ Urease used probably contained small quantities of ammonia, thereby rendering this value doubtful.

113. EXCRETION OF NITROGEN COMPOUNDS: MAN

Because of the high degree of variability in rate of sweat formation, ranging from zero under some conditions, up to as high as 12 liters per day in extremely hot climates, it has not been practicable to present data on excretion via sweat in terms of "per kg body weight per day".

	Constituent	Excreted in Urine		Excreted in Feces		Excreted in Sweat	
		mg/kg body wt/da		mg/kg body wt/da		mg/100 ml	
		Value	Range[1]	Value	Range[1]	Value	Range[1]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Water, total	17,000	7,800-27,500		910-1,820		
2	Solids, total	860	780-1,000	394	140-560		
3	Nitrogen, total[2,3]	347	85-500	24	11.4-36.0	31.0	27-64
4	Protein nitrogen		0.0046-0.018				
5	Non-protein nitrogen[3]	347	85-500			31.0	27-64
6	Amino acid nitrogen	2.5	2.2-4.4			4.4	1.57-4.76
7	Creatinine	15	12-25			4.25	0-6.68
8	Hippuric acid	8	1-12				
9	Urea	300	215-500			72	25-186
10	Uric acid	9	5-12			1.4	0.7-2.5
11	Ammonia[4]	9.2	4-18.2		0.36-1.2		2.5-35
	Amino Acids						
12	Alanine, free						
13	Combined						
14	Total	0.55					
15	Arginine, free	0.31	0.15-0.5				
16	Combined	0.1	0-0.2				
17	Total	0.4	0.34-0.5	3.8	2.9-5.0	13.5	5.8-21.4
18	Aspartic acid, free	0.02	0.014-0.26				
19	Combined	2.3	1.2-3.7				
20	Total	2.32	0.37-3.7				
21	Citrulline, free[5]	0.58	0.26-0.7				
22	Combined						
23	Total		0.345-0.79				
24	Cystine, free	1.3	0.65-2.0				
25	Combined						
26	Total		1.5-2.4				
27	Glutamic acid, free	0.52	0-1.07				
28	Combined	4.5	1.0-10.0				
29	Total	5.27	1.58-11.55				
30	Glycine, free	10.1	9.0-12.0				
31	Combined						
32	Total		2.3-18.0				
33	Histidine, free	2.7	0.94-4.8				
34	Combined	0.6	0.07-1.8				
35	Total	.3	0.98-6.59	1.7	1.4-2.1	8.0	6-10

/1/ Ranges are averages of ranges of values reported in the literature cited. They may be considered to be equivalent to estimate "d" of the 95% range (cf. Introduction). /2/ Nitrogen in excreta is present as nitrogen compounds and not as free nitrogen. /3/ Total N, and NPN values have been calculated from the values listed for the individual nitrogen components, Items No.6-11. See also Footnote 1. /4/ See also table on electrolyte excretion. /5/ Determined by paper chromatography, identity not completely proven.

113. EXCRETION OF NITROGEN COMPOUNDS: MAN (Continued)

Because of the high degree of variability in rate of sweat formation, ranging from zero under some conditions, up to as high as 12 liters per day in extremely hot climates, it has not been practicable to present data on excretion via sweat in terms of "per kg body weight per day".

	Constituent	Excreted in Urine		Excreted in Feces		Excreted in Sweat	
		mg/kg body wt/day		mg/kg body wt/da		mg/100 ml	
		Value	Range[1]	Value	Range[1]	Value	Range[1]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
	Amino Acids (concluded)						
36	Hydroxyproline, free						
37	Combined						
38	Total	0.02					
39	Isoleucine, free	0.085	0.03-0.3				
40	Combined	0.2	0.06-0.4				
41	Total	0.3	0.11-0.6	4.3	3.3-5.5	2.3	1.0-3.6
42	Leucine, free	0.14	0.05-0.25				
43	Combined	0.2	0.05-0.4				
44	Total	0.32	0.2-0.52	5.6	4.3-6.9	2.7	1.2-4.2
45	Lysine, free	0.5	0.25-1.13				
46	Combined	0.6	0.2-1.1				
47	Total		0.48-2	5.7	4.5-6.9	2.3	1.4-3.2
48	Methionine, free	0.11	0.05-0.18				
49	Combined	0.03					
50	Total	0.14	0.12-0.17				
51	Ornithine, free[2]	0.15					
52	Combined						
53	Total						
54	Phenylalanine, free	0.23	0.1-0.43				
55	Combined	0.1	0.04-0.2				
56	Total	0.33	0.21-0.6			2.2	1.0-3.5
57	Proline, free	0.12	0.05-0.21				
58	Combined	0.5	0.3-0.8				
59	Total	0.61	0.33-0.9				
60	Serine, free	0.4	0.21-0.52				
61	Combined	0.25	0-0.5				
62	Total	0.65	0.35-1.4				
63	Threonine, free	0.37	0.17-0.62				
64	Combined	0.4	0.3-0.8				
65	Total	0.77	0.36-1.2	4.0	3.3-5.2	5.4	1.7-9.1
66	Tryptophan, free	0.37	0.12-0.7				
67	Combined	0.3	0.009-0.4				
68	Total	0.7	0.23-1.3			1.1	0.4-1.8
69	Tyrosine, free	0.3	0.17-0.55				
70	Combined	0.5	0.08-0.9				
71	Total	0.79	0.35-1.45			3.2	1.2-5.0
72	Valine, free	0.065	0.04-0.125				
73	Combined	0.2	0.09-0.4				
74	Total	0.3	0.21-0.45	4.6	3.6-6.2	3	1.5-4.5

/1/ Ranges are averages of ranges of values reported in the literature cited. They may be considered to be equivalent to estimate "d" of the 95% range (cf. Introduction). /2/ Identity not proven.

113. EXCRETION OF NITROGEN COMPOUNDS: MAN (Concluded)

Because of the high degree of variability in rate of sweat formation, ranging from zero under some conditions, up to as high as 12 liters per day in extremely hot climates, it has not been practicable to present data on excretion via sweat in terms of "per kg body weight per day".

	Constituent	Excreted in Urine		Excreted in Feces		Excreted in Sweat	
		mg/kg body wt/da		mg/kg body wt/da		mg/100 ml	
		Value	Range[1]	Value	Range[1]	Value	Range[1]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
	Miscellaneous Compounds						
75	Methionine sulfoxide		0-0.31				
76	Indican	0.14	0.06-0.45				
77	Adrenaline[6]	0.16µg	0.07-0.31µg				
78	Taurine		0.105-0.2				
79	Allantoin	0.27	0.18-0.36				
80	Noradrenaline[6]	0.41µg	0.17-0.9µg				
81	Purine bases	0.41	0.18-0.92		2-3		
82	Guanidoacetic acid		0.23-0.51				
83	Histamine		0.2-1.0				
84	Creatine[7]	2.9	1.1-3.86				
85	Hydroxytyramine[6]		1.4-2.8µg				
86	Imidazole derivatives		1.35-9.4		0-0.2		

/1/ Ranges are averages of ranges of values reported in the literature cited. They may be considered to be equivalent to estimate "d" of the 95% range (cf. Introduction). /6/ The catechol amines expressed in micrograms. /7/ Not normally present in the urine of adult males.

114. EXCRETION OF LIPIDS: MAN

	Constituent	Excreted in Urine		Excreted in Feces		Excreted in Sweat		Excreted in Sebum[1]
		mg/kg body wt/da		mg/kg body wt/da		mg/100 ml		g/100 g
		Value	Range[2]	Value	Range[2]	Value	Range[2]	Value
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
1	Fat, total			56	30.0-100			
2	Fat, neutral				10-45			
3	Fat, unsaponifiable			33	22-38[3]			
4	Fatty acids, total			30	4-64			
5	Fatty acids, free			16	4-38			28
6	Fatty acids, unsaturated							15[4]
7	Cholesterol, total		0-0.007	8[5]	10-20[5]			5[4]
8	Cholesterol, free							2.5[4]
9	Paraffin							7.5[4]
10	Phosphatides							0.9[6]
11	Soaps			53[3]	40-66			
12	Squalene							5[4]
13	Triglycerides							33[4]
14	Waxes[7]							15[4]

/1/ The data on sebum are not available in mg per kg body weight per day, and are therefore presented in grams per 100 grams. /2/ Ranges are averages of ranges of values reported in the literature cited. They may be considered to be equivalent to estimate "d" of the 95% range (cf. Introduction). /3/Age 8-12 yr. /4/From forearms only. /5/ Age 10 months. /6/Individual samples from forehead. /7/ Include esters of cholesterol.

115. EXCRETION OF VITAMINS AND HORMONES: MAN

Because of the high degree of variability in rate of sweat formation, ranging from zero under some conditions, up to as high as 12 liters per day in extremely hot climates, it has not been practicable to present data on excretion via sweat in terms of "per kg body weight per day".

	Constituent	Excreted in Urine		Excreted in Feces		Excreted in Sweat	
		µg/kg body wt/da		µg/kg body wt/da		µg/100 ml	
		Value	Range[1]	Value	Range[1]	Value	Range[1]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
	Vitamins						
1	Vitamins A, D, K		0-trace				
2	Ascorbic acid	380	130-790	70	60-70		0-200[2]
3	Biotin	0.4	0.33-0.75	1.9	0.63-6.64	trace[3]	
4	Carotenes				20-600[4]		
5	Choline	90	80-130				2.7-15.3
6	Cobalamin[5]	0.0004	0.00023-0.00079				
7	Vitamin E[6]			308	226-391		
8	Folic acid group[7]	0.2	0.03-0.3	4.3	1.8-7.7	0.6	0.53-0.88
9	Inositol	170	170-220			21	15-36
10	Nicotinic acid		11-105	52	12-124		7-22
11	N-Methyl nicotinamide	130	73-400				
12	Pantothenic acid	44	20-100	31.4	3.85-63.4	3.8	2.2-4.4
13	Para-aminobenzoic acid	2.11	2-3	3.5	1.01-8.2	0.24	0.08-1.7
14	Pyridoxine		0.007-0.0098	5.4	2.4-10.4	0.084	0.08-0.18
15	Pyridoxal	3.0	0.7-5.4			3.2	0.4-8.25
16	Pyridoxamine	1.6	0.3-2.1				
17	4-Pyridoxic acid	51	9-160				
18	Riboflavine	14.3	0.2-22.5	14.7	8.0-23		0-0.5
19	Thiamine	2.6	0.43-5.6	7.8	0.67-18	0.015	0-0.6
20	Trigonelline		30-300				
	Hormones						
21	Androgens		30-100				
22	Estrogens		0.1-0.5				
23	Formaldehydogenic steroids		3-140				
24	17-Ketosteroids	♂160;♀100					
25	Oxycorticosteroids		1.0-6.0				

/1/ Ranges are averages of ranges of values reported in the literature cited. They may be considered to be equivalent to estimate "d" of the 95% range (cf. Introduction). /2/ Ascorbic and dehydroascorbic acid. /3/ Present but not quantitated. /4/ Carotene and xanthophyll; 8-100 µg/kg body wt/da for xanthophyll alone. /5/ A generic term including cyanocobalamin (vitamin B_{12}) and its hydrogenation product (known variously as B_{12a} or B_{12b}) which has approximately the same biological activity. /6/ A generic term for alpha-, beta-, delta-, and gamma-tocopherols. /7/ Folic acid is not a chemical entity, but a generic term for pteroylglutamic acid (folacin), vitamin M, vitamin B_c, factor U, L. casei factor, Norite eluate factor.

116. EXCRETION OF MISCELLANEOUS ORGANIC COMPOUNDS: MAN

Because of the high degree of variability in rate of sweat formation, ranging from zero under some conditions, up to as high as 12 liters per day in extremely hot climates, it has not been practicable to present data on excretion via sweat in terms of "per kg body weight per day".

	Constituent	Excreted in Urine per kg body wt/da		Excreted in Feces per kg body wt/da		Excreted in Sweat per 100 ml	
		Value	Range[1]	Value	Range[1]	Value	Range[1]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Acetone bodies, mg	0.285	0.03-0.7				
2	Reducing substances, mg		7-20			3.08	0-16
3	Sugars, as glucose, mg	1.4					2.8-40
4	Volatile acids, total, ml. of 0.1 N			2.66	1.61-4.45		2.4-5.6
		Organic Acids					
5	Citric acid, mg		3-17			0.2	
6	Formic acid, mg		0.4-2				
7	Indole acetic acid, mg		0.03-0.06				
8	Lactic acid, mg	40				225	45-452
9	Oxalic acid, mg	0.285	0.23-0.5				
10	Phenols, mg	4	0.19-6.6		0-3		2-8
		Pigments					
11	Bilirubin, µg	70					
12	Coproporphyrin I, and III, µg		0.24-1.4				
13	Urobilin, µg		7-20				
14	Urobilinogen, µg		0.6-3	2	0.57-4		
15	Porphyrins, µg		0-0.4				

/1/ Ranges are averages of ranges of values reported in the literature cited. They may be considered to be equivalent to estimate "d" of the 95% range (cf. Introduction).

117. EXCRETION OF ELECTROLYTES AND MINOR MINERALS: MAN

Because of the high degree of variability in rate of sweat formation, ranging from zero under some conditions, up to as high as 12 liters per day in extremely hot climates, it has not been practicable to present data on excretion via sweat in terms of "per kg body weight per day".

	Constituent	Excreted in Urine		Excreted in Feces		Excreted in Sweat	
		per kg body wt/da		per kg body wt/da		per 100 ml	
		Value	Range[1]	Value	Range[1]	Value	Range[1]
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	Aluminum, µg		0.7-1.6	0.6			
2	Ammonia[2], µg	9,200	4,900-18,200		360-1,200		2,500-35,000
3	Arsenic, µg	0.46	0-1.15	33	1-116		
4	Bromine, µg		12-110				
5	Calcium, µg	2,900	1,100-4,910	7,490	5,000-10,000	2,060	100-5,500
6	Chlorine[3], mg	115	84-193		0.21-0.5		30-300
7	Cobalt, µg	0.07	0.05-0.12	0.007	0.002-0.02		
8	Copper, µg	2.38	0-7.52	27	23-37	6.0	
9	Fluorine[4], µg		6.7-100[5]				
10	Iodine[6], µg	1.4	0.2-2.13			0.8	0.5-1.2
11	Iron, µg	0.7	0.7-1.4	120	65-208	27	22-45
12	Lead, µg	0.5	0.06-2.1	4.2	2.2-19.8		
13	Magnesium, µg	1,850	950-4,500	2,500	1,510-3,185	200	140-4,500
14	Manganese, µg		0.095-1.4		18-120	6	3-7
15	Mercury, µg		0.007-0.01	0.14			
16	Nickel, µg	2.1	2-4		1.2-2.5		
17	Nitrates, µg	7,140					
18	Phosphorus, mg	15	10-19	9.86	7.1-20	1.5	0-4.8
19	Potassium, mg	34	14-46	6.7			21-126
20	Selenium, µg	1	0-3.3				
21	Silicon, µg	108	14-200				
22	Silver, µg			0.8			
23	Sodium, mg	46	38-91	1.7			29-294
24	Sulfur, total, mg	16.5	4-40	2.0			0.7-7.4
25	Sulfur, ethereal, mg	1	0.6-4.3				
26	Sulfur, inorganic, mg	12.5	3.5-18.25				
27	Sulfur, neutral, mg	1.9	1.0-3.0				
28	Tin, µg		0.13-0.31		170-450		
29	Zinc, µg	4.6	1-6.4	101	46-500		

/1/ Ranges are averages of ranges of values reported in the literature cited. They may be considered to be equivalent to estimate "d" of the 95% range (cf. Introduction). /2/ See also table on excretion of nitrogen compounds. /3/ Chloride. /4/ Fluoride. /5/ Data include regions in Texas where dental fluorosis is endemic. /6/ Iodide. /7/ For ages 8-12 yr.

118. PRODUCTS OF CARBOHYDRATE METABOLISM: MOLDS

Products listed include only compounds (both diffusible and confined to the mycelium) which are produced on media containing glucose or sucrose, by the more common fungi (Mucor, Rhizopus, Aspergillus, Penicillium, Alternaria, Helminthosporium). The well-known antibiotics have been omitted. The organisms listed do not constitute the only species producing the compound, but rather the more common ones in many cases, or those used industrially. Most figures on yield are approximate, as they are frequently based on weights of crude product, or of pure material after losses in purification. Strains of one species may differ widely as regards yield.

	Metabolic Product	Produced By	Yield
	(A)	(B)	(C)
	Organic Acids, Aldehydes, Alcohols and Related Compounds		
1	Acetaldehyde	Various Penicillia, Aspergilli, A. niger, Mucor species, and many other genera. By fixation with intercepting agents.	Up to 60% of theory when grown on sucrose with Aspergillus niger.
2	Acetic acid	Fomes annosus, Marasmius chordalis, Merulius confluens, M. lachrymans, M. niveus, M. tremellosus.	0.6% - 0.9% of glucose used for Merulius lachrymans and Marasmius chordalis.
3	Aconitic acid	Aspergillus niger.	
4	Ascorbic acid	Aspergillus niger.	0.2% of the glucose consumed.
5	Byssochlamic acid	Byssochlamys fulva.	0.5% of the glucose consumed.
6	Carlic acid	Penicillium charlesii.	Up to 1.1% of the sugar consumed.
7	Carlosic acid	Penicillium charlesii, P. cinerascens.	Up to 0.36% of the sugar consumed.
8	Carolic acid	Penicillium charlesii.	Up to 1.54% of the sugar consumed.
9	Carolinic acid	Penicillium charlesii.	Up to 0.9% of the sugar consumed.
10	Clavacin[1] (claviformin or patulin)	Aspergillus clavatus, Penicillium expansum, P. claviforme, P. patulum.	2.2% of glucose added.
11	Clavatol	Aspergillus clavatus.	Small amount.
12	Citric acid	Citromyces, Penicillium luteum, P. citrinum, P. spinulosum, Aspergillus niger, A. clavatus, A. itaconicus, A. wentii, Mucor pyriformis, many other species. Commercial production on beet and cane molasses. Submerged production possible but not yet commercially successful.	As high as 90% of theory.
13	Cyclopaldic acid	Penicillium cyclopium Westling var. album G. Smith.	0.97% of dry mycelium.
14	Cyclopolic acid	Penicillium cyclopium Westling, P. cyclopium Westling var. album G. Smith.	5.45% of dry mycelium in P. cyclopium Westling; 1.65% of dry mycelium in P. cyclopium var. album.
15	Dehydrocarolic acid[2]	Penicillium cinerascens.	3% of the glucose consumed.
16	Dihydrogladiolic acid	Penicillium gladioli.	340 mg/liter of Raulin - Thom medium.
17	Dimethyl pyruvic acid	Aspergillus niger. In presence of sodium sulfite as interceptor.	
18	i-Erythritol	Penicillium brevi-compactum, P. cyclopium.	0.7% of the weight of the organism.
19	Ethyl acetate	Penicillium digitatum	0.6% of the sugar consumed.
20	Ethyl alcohol	Fusarium species, Mucor species, Merulius species, various Penicillia and Aspergilli, Fomes annosus. Production much slower than by yeast.	Stoichiometric yield with Fusaria, Merulius species, Fomes annosus grown on hexoses and pentoses.
21	L-Ethylene oxide α, β dicarboxylic acid	Monilia formosa n. sp., Penicillium viniferum n. sp., Aspergillus fumigatus.	10-15% yield from various substrates; hexoses, hexahydric alcohols, pentoses, pentahydric alcohol, erythritol, 2,3, butylene glycol, glycerol, acetate and alcohol.
22	Formic acid	Aspergillus oryzae.	
23	Fumaric acid	Various species of Rhizopus; Aspergillus fumaricus, Penicillium griseofulvum, Caldariomyces fumago. Most species other than Mucorales give small amounts.	50% of theoretical yield after 30 days.
24	Fumaroalanide	Penicillium reticulosum.	3.3 g from 1750 g glucose furnished.
25	Fumigacin[1]	Aspergillus fumigatus, A. fumigatus mut. helvola	0.02 - 0.15% of the glucose added.
26	Gentisic acid	Penicillium griseofulvum.	0.1% of the glucose consumed.
27	Gentisyl alcohol	Penicillium patulum.	2.3% of the glucose added.
28	Gladiolic acid	Penicillium gladioli.	94 mg/liter of Raulin-Thom medium.
29	Glaucic acid	Aspergillus glaucus.	
30	Glauconic acid	Green Penicillium sp.	20% of a mixture.

/1/ Possesses antibiotic properties but is not in clinical use. /2/ See also Carolic acid.

118. PRODUCTS OF CARBOHYDRATE METABOLISM: MOLDS (Continued)

	Metabolic Product	Produced By	Yield
	(A)	(B)	(C)
	Organic Acids, Aldehydes, Alcohols and Related Compounds (cont'd)		
31	Gluconic acid	Penicillium chrysogenum, P. luteum, P. purpurogenum, Aspergillus species, Fusarium lini Bolley.	Practically quantitative conversion in 24 hours.
32	Glucose	Aspergillus niger. From tartaric acid, lactic acid, mannitol and quinic acid.	
33	Glucosone	Aspergillus parasiticus, A. flavus.	8% from glucose. 13-17% from sucrose, maltose, starch.
34	Glutaconic acid	Aspergillus niger strains.	
35	Glutaric acid	Aspergillus niger strains.	
36	Glycerol	Mucor racemosus, Aspergillus wentii, white Aspergilli, Clasterosporium and Helminthosporium.	Usually small amounts; some species, 3% of the glucose consumed.
37	Glycolic acid	Aspergillus niger (from acetate).	Tracea.
38	Glycuronic acid	Ustulina vulgaris.	
39	Glyoxylic acid	Aspergilius niger (from acetate), Merulius lachrymans.	Traces.
40	2-Hydroxymethyl-furane-5-carboxylic acid	Aspergillus glaucus, A. clavatus, A. niger, A. oryzae, A. wentii.	
41	Itaconic acid	Aspergillus terreus, A. itaconicus.	As high as 50% of theoretical yield
42	Itatartaric acid	Aspergillus terreus mutant.	1.5% of glucose added.
43	γ-Ketopentadecoic acid	Penicillium minio-luteum, P. spiculisporum.	2.5% of the glucose consumed.
44	Kojic acid	Aspergillus flavus - oryzae - tamarii group, A. wentii.	45-55% in 12 days. 63-66% reported.
45	D-Lactic acid	Practically confined to Mucorales. Various Rhizopus species, i.e., R. stolonifer, oryzae, japonicus, tritici, arrhizus. Fumaric acid produced by altering conditions.	Up to 62% with R. oryzae, 39-40% with R. japonicus.
46	Malic acid	White species of Aspergillus, A. flavus, Clasterosporium sp. Accompanied by succinic and fumaric acids.	Fair yields by submerged growths when growing at low temperatures.
47	Malonic acid	Penicillium funiculosum.	
48	Mannitol	White species of Aspergillus, many Aspergilli, Byssochlamys fulva, Penicillium griseofulvum. Not produced from fructose.	45-50% of theory.
49	Mannonic acid	Penicillium purpurogenum var. rubrisclerotium. On D-mannose.	9% yield.
		Certain Aspergillus niger strains. On mannose.	70% yield.
		Certain A. niger strains. On galactose.	High yield.
50	Mellein[3] (ochracin)	Aspergillus melleus, A. ochraceus.	300 mg/l of medium on sucrose.
51	Methyl glyoxal	Aspergillus niger. On hexosediphosphate.	16% of the substrate consumed.
52	Methyl salicylic acid	Penicillium griseofulvum, P. flexuosum.	2.4% of the glucose consumed.
53	γ-Methyl tetronic acid	Penicillium charlesii.	Up to 0.52% of the sugar consumed.
54	Minioluteic acid[4]	Penicillium minio-luteum	2.5% of the glucose consumed.
55	Mycophenolic acid	Penicillium brevi-compactum, P. stoloniferum.	0.95% of the glucose consumed.
56	Oxalic acid	Citromyces, Aspergillus, Penicillium and many other genera. Can be produced more economically by other methods.	50% of the sugar consumed.
57	Palitantin	Penicillium palitans	About 1% of the glucose consumed.
58	Penicillic acid[1]	Penicillium cyclopium, P. puberulum, Aspergilli.	4.2% of the glucose consumed.
59	Penicillium brevicompactum acids: I	Penicillium brevi-compactum.	0.9% of the sugar consumed.
60	Penicillium brevicompactum acids: II	Penicillium brevi-compactum.	0.1% of the sugar consumed.
61	Penicillium brevicompactum acids: III	Penicillium brevi-compactum.	0.9% of the sugar consumed.
62	Penicillium brevicompactum acids: IV	Penicillium brevi-compactum.	0.03% of the sugar consumed.
63	Propionic acid	Botrytis cinerea. On lactate.	
64	Puberulic acid[5]	Penicillium puberulum.	0.66% of the glucose consumed. (crude).
65	Puberulonic acid[5]	Penicillium puberulum.	
66	Pyruvic acid	Aspergillus niger (in presence of sodium sulfite as interceptor), Fusarin.	8.2% of the glucose consumed.

/1/ Posseasca antibiotic properties but is not in clinical use. /3/ Converted to methyl salicylic acid on KOH fusion. /4/ Related to spiculisporic acid. /5/ Tropolone derivative.

118. PRODUCTS OF CARBOHYDRATE METABOLISM: MOLDS (Continued)

	Metabolic Product	Produced By	Yield
	(A)	(B)	(C)
	Organic Acids, Aldehydes, Alcohols and Related Compounds (concluded)		
67	Saccharic acid	Aspergillus niger.	
68	Sorbicillin	Penicillium notatum.	
69	Spiculosporic acid[6]	Penicillium spiculisporum, P. crateriforme, P. minio-luteum.	Approx. 2% of the sugar utilized.
70	Stipitatic acid[5]	Penicillium stipitatum.	Up to 3% of the sugar consumed.
71	Succinic acid	Mucor stolonifer, Aspergillus terreus, Ustulina vulgaris, Penicillium aurantio-virens, P. spiculosporum, Fusarium oxysporum, heterosporum and lini Bolley, Fomes annosus, Merulius confluens, M. niveus, M. tremellosus.	Yields very small, except for Fusarium species.
72	Sulochrin	Oospora sulphureaochracea.	5% of the mycelium.
73	Terrein	Aspergillus terreus.	(crude) 2-3% of the glucose consumed.
74	Terrestric acid (ethyl carolic acid)	Penicillium terrestre.	2.4% of the sugar consumed.
75	Ustic acid	Aspergillus ustus.	0.6% of glucose added.
	Pigments		
76	Alboleersin (colorless)[7]	Helminthosporium leersii.	7.4% of mycelial weight.
77	Aurofusarin	Fusarium culmorum, F. graminearum.	Up to 4.4% of mycelial weight.
78	Auroglaucin	Aspergillus glaucus sp.	More than 13% of the dry growth.
79	β-Carotene	Neurospora, Mucor hiemalis, Phycomyces blakesleanus.	Traces.
80	γ-Carotene	Allomyces species.	Traces.
81	Carviolacin	Penicillium roseopurpureum (P. carminoviolaceum).	3.0% of mycelium (crude pigment).
82	Carviolin	Penicillium roseopurpureum (P. carminoviolaceum).	3.0% of mycelium (crude pigment).
83	Catenarin[8] (1-hydroxy-emodin)	Helminthosporium catenarium, H. gramineum, H. velutinum, H. tritici-vulgaris.	As much as 10% - 40% of the mycelial weight in Helminthosporium gramineum, 20% in H. catenarium.
84	Chrysogenin	Penicillium chrysogenum.	
85	Chrysophanic acid (chrysophanol)	Penicillium islandicum.	0.1% of dried mycelium.
86	Citrinin[1]	Penicillium citrinum, Aspergillus terreus.	3.4% of the sugar consumed.
87	Citromycetin	Citromyces glabrum (Penicillium frequentans group).	As much as 20% sugar metabolized.
88	Culmorin (colorless)	Fusarium culmorum, F. graminearum.	Up to 4.64% of the mycelium. Isolated along with aurofusarin.
89	Cynodontin[8]	Helminthosporium cynodontis, H. euchlaenae, H. avenae.	Up to 4.2% of mycelium
90	Emodic acid	Penicillium cyclopium.	0.1% (as acetyl derivative) of glucose supplied.
91	Ergochrysin	Sclerotium clavus.	
92	Ergoflavin	Sclerotium clavus.	
93	Erythroglaucin	Aspergillus glaucus group, 15 species.	0.25% of the mycelium (pure).
94	Flavoglaucin	Aspergillus glaucus.	More than 25% of the dry growth weight.
95	Fulvic acid	Penicillium griseofulvum, P. flexuosum, P. brefeldianum.	15-20% of the mycelium, 2.7% of the glucose consumed.
96	Fumigatin	Aspergillus fumigatus.	0.35% of the glucose consumed (crude material).
97	Funiculosin (trihydroxy-methyl-anthraquinone)	Penicillium funiculosum.	
98	Fusarubin	Fusarium solani	On sucrose 25 mg/liter of medium.
99	Helminthosporin[7]	Helminthosporium gramineum, H. catenarium, H. tritici-vulgaris, H. cynodontis.	As much as 22% - 40% of the mycelial weight in H. gramineum.
100	ω-Hydroxy emodin	Penicillium cyclopium, P. citreo-roseum, P. cyaneo-fulvum.	0.1/ of glucose (tetraacetyl derivative) supplied.
101	3-hydroxy-4-methoxy-toluquinol[9]	Aspergillus fumigatus.	
102	Islandicin	Penicillium islandicum.	3% of the mycelium.
103	Javanicin	Fusarium javanicum.	0.05% of the glucose added (pure).
104	Luteoleersin[10]	Helminthosporium leersii.	1.8% of the mycelium.

/1/ Possesses antibiotic properties but is not in clinical use. /5/ Tropolone derivative. /6/ Related to minioluteic acid. /7/ Related to luteoleersin. /8/ Compare items no. 83, 89, 99, and 123. Different species of Helminthosporium have different proportions of these pigments. /9/ Reduced form of fumigatin. /10/ Related to alboleersin.

118. PRODUCTS OF CARBOHYDRATE METABOLISM: MOLDS (Continued)

	Metabolic Product (A)	Produced By (B)	Yield (C)
	Pigments (concluded)		
105	Lycopersin	Fusarium lycopersici.	
106	Monascoflavin	Monascus purpureus.	
107	Monascorubrin	Monascus purpureus.	
108	Nalgiovensin	Penicillium nalgiovensis.	1% of dry mycelium.
109	Oosporein	Oospora colorans.	9.5% of the substrate added.
110	Oxy-javanicin	Fusarium javanicum.	0.02% of the glucose added (pure).
111	Penetrinic acid	Penicillium notatum.	
112	Penicilliopsin	Penicilliopsis clavariaeformis.	7.5% of the mycelium.
113	Phoenicin	Penicillium phoeniceum, P. rubrum (Also Bacillus pyocyaneus)	1.2% (pure) of mycelium.
114	Physcion (Emodin monomethyl ether)	Aspergillus glaucus species.	0.65% of the mycelium (pure).
115	Physcion anthranol A (4,5 dihydroxy-7-methoxy-2-methyl-9-anthranol)	Aspergillus glaucus.	Very small amount.
116	Physcion anthranol B (4,5 dihydroxy-7-methoxy-2-methyl-10-anthranol)	Aspergillus glaucus.	Very small amount.
117	Ravenelin	Helminthosporium ravenelii, H. turcicum.	10% of the mycelium.
118	Rubrofusarin	Fusarium culmorum, F. graminearum.	Up to 1.15% of mycelial weight. Crude pigment up to 8.7% of mycelial weight.
119	Rugulosin	Penicillium rugulosum.	
120	Solanione	Fusarium solani D_2 purple.	
121	Spinulosin (6-hydroxy-fumigatin)	Penicillium spinulosum, P. cinerascens, Aspergillus fumigatus.	0.11% of the glucose consumed (A. fumigatus).
122	Tetrahydrophoenicin (leucophoenicin)	Penicillium rubrum.	
123	Tritisporin[8]	Helminthosporium tritici-vulgaris, Helminthosporium species.	1.4% of the mycelium.
	Chlorine - containing Compounds		
124	Caldariomycin	Caldariomyces fumago.	0.4% of the glucose consumed.
125	Erdin[11]	Aspergillus terreus.	0.6% of the sugar consumed.
126	Geodin[11]	Aspergillus terreus.	0.6% of the sugar consumed.
127	Griseofulvin[1]	Penicillium griseofulvum, P. janczewskii.	2% of the mycelium.
128	Nalgiolaxin[12]	Penicillium nalgiovensis.	0.18% of dry mycelium.
129	Sclerotiorine	Penicillium sclerotiorum.	2% of the mycelium.
	Polysaccharides		
130	Capreolinose[13]	Penicillium capreolinum.	
131	Glycogen[14] (red-brown I_2 color)	White species of Aspergillus, Penicillium digitatum.	
132	Gums	Oidium sp., Penicillium lactis, P. guttulosum, Monilia candida, Mucor racemosus	38% on 10% mannose.
133	Levan[15]	Aspergillus sydowii.	(from sucrose only).
134	Luteic acid (Luteose)[16]	Penicillium luteum.	10-12%.
135	Mold starch[14] (blue I_2 color)	Penicillium species.	
136	Mycodextran[14] (no I_2 color)	Penicillium expansum, Aspergillus niger.	2% of the growth.
137	Mycogalactan[17]	Aspergillus niger (produced along with Mycodextran).	
138	Polygalactose[17] (galactocarolose)	Penicillium charlesii.	Approx. 4% of the sugar consumed. (crude)
139	Polymannose[18]	Penicillium charlesii.	Approx. 4% sugar consumed (crude).
140	Rugulose[17]	Penicillium rugulosum.	
141	Sclerotiose[14]	Penicillium sclerotiorum.	10% of the mycelial weight.

/1/ Possesses antibiotic properties but is not in clinical use. /8/ Compare items no. 83, 89, 99, and 123. Different species of Helminthosporium have different proportions of these pigments. /11/ Geodin and erdin are closely related compounds. /12/ Mono-chloro-nalgiovensin. /13/ Hydrolysis yields mannose, glucose, galactose and mannonic acid. /14/ Hydrolysis yields glucose. /15/ Hydrolysis yields fructose. /16/ Hydrolysis yields B-glucose-malonic acid (2:1), demalonylated luteic acid. /17/ Hydrolysis yields galactose. /18/ Hydrolysis yields mannose.

118. PRODUCTS OF CARBOHYDRATE METABOLISM: MOLDS (Concluded)

	Metabolic Product (A)	Produced By (B)	Yield (C)
	Polysaccharides (concluded)		
142	Varianose[19]	Penicillium varians.	Approx. 1% of the glucose consumed (crude material)
	Sterols and Lipids		
143	Cerebrin	Aspergillus sydowii.	0.1-0.4%
144	Cerebronylsphingosine compounds	Aspergillus citromyces.	
145	Ergosterol	Aspergillus niger, A. oryzae, Fusarium lycopersici, F. lini Bolley, Helminthosporium avenae, H. ravenelii, H. velutinum, Lentinus lepideus, Penicillium expansum, P. puberulum.	0.13% - 1.7% of mycelium.
146	Ergosteryl palmitate	Penicillium brevi-compactum, P. italicum.	0.5% of the growth, 0.6% of the glucose consumed.
147	Fat	All organisms.	Various.
148	Lecithin	Aspergillus oryzae (spores).	
149	Lecithin and cephalin	Aspergillus sydowii.	0.43-0.73%
150	Phosphatides	Aspergillus oryzae, A. sydowii, A. citromyces	
151	Sterols	Aspergillus fischeri, Penicillium puberulum, Paecilomyces varioti, Fusaria	0.13%-1.0% of the dry mycelium.
	Nitrogen Containing Compounds		
152	Adenine	Aspergillus niger.	0.05%
153	Aspergillic acid	Aspergillus flavus.	1% of the carbohydrate added.
154	Betaine	Aspergillus oryzae (spores).	
155	Choline sulphate	Aspergillus sydowii (from hydrolysis of mycelium)	
156	Hypoxanthine	Aspergillus oryzae, Rhizopus japonicus.	
157	Lycomarasmin (asparagyl-glycylhydroxyalanine)	Fusarium lycopersici	110 mg/l of medium on glucose.
158	Stachydrine (n-methyl-proline-methyl betaine)	Aspergillus oryzae, Rhizopus japonicus.	
159	Thiamine	Fusarium lini Bolley.	20 gammas/gram of mycelium.
160	Urea	Penicillium johannioli, Aspergillus niger, Rhizopus nigricans.	
161	Uric acid	Aspergillus oryzae (spores).	

/19/ Hydrolysis yields D-glucose, D-galactose and D-idose or L-altrose.

119. PRODUCTS OF CARBOHYDRATE METABOLISM AS AFFECTED BY CHANGE IN pH: YEASTS AND BACTERIA

Values represent mM of product per 100 mM glucose fermented. Higher values have been rounded to nearest whole number.

	Organism and pH[1]	Bacillus subtilis		Aerobacter aerogenes		Serratia marcescens		Escherichia coli		Saccharomyces cerevisiae	
	Product	pH6.2	pH7.6	pH6.0	pH8.0	pH6.4	pH7.8	pH6.0	pH7.8	pH3.0	pH7.6
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Acetic acid	1.2	12.8	8.0	53	1.9	49.	36	39	0.5	15.1
2	Acetoin	2.7	3.0	1.6	5.8	1.6	5.9	0.1	0.2	0	0.2
3	2,3-Butanediol	40	11.8	48	0	55	0	0.3	0.3	0.8	0.7
4	CO_2	86	32	174	19.6	116	2.2	88	1.7	181	149
5	Ethanol	15.1	22.3	57	61	47	41	50	50	172	130
6	Formic acid	16.6	40	0.8	120	46	91	2.4	86	0.4	0.5
7	Glycerol	31	10.3	3.3	6.6	2.2	9.6	1.4	0.3	6.2	32
8	H_2	0.5	0.3	74	10.4	0.8	0.2	75	0.3		
9	Lactic acid	66	119	3.4	9.8	9.7	65	80	70	0.8	1.4
10	Succinic acid	0.7	2.2	1.8	9.3	2.9	4.8	10.7	14.8	0.5	0.7

/1/ The pH was electronically controlled using ammonium hydroxide to neutralize the acids formed.

120. PRODUCTS OF CARBOHYDRATE METABOLISM OF INDUSTRIAL IMPORTANCE: BACTERIA

	Main Product	Organism	Raw Materials (Substrate)	Conditions
	(A)	(B)	(C)	(D)
1	Acetone, butanol	Clostridium aceto-butylicum, etc.	Molasses, corn, starches	pH 5-7, 37-40°C, 48-78 hours
2	Butylene glycol[1]	Aerobacter aerogenes, Bacillus polymyxa and certain other aerobic bacilli	Grains, molasses, starches	pH 5-6.5, 30°C, 3-4 days
3	Dextran	Leuconostoc mesenteroides	Sucrose	
4	Lactic acid	Lactobacillus delbrueckii and other species; Streptococcus lactis, etc.	Molasses, whey	pH 7, 40-50°C[2] 42 hours
5	l-Sorbose	Acetobacter suboxydans	d-Sorbitol	28°C, 14-45 hours

/1/ Has been produced on a pilot-plant scale; industrial production practicable but not in progress. /2/ The temperature depends on the bacterial species used.

121. METABOLIC PRODUCTS OF BACTERIA: ANAEROBIC FERMENTATION OF GLUCOSE

Ten groups of organisms are represented, each by a single member of the group. All members in a group produce from glucose the same compounds in similar proportions. All members of a single group are, therefore classified as belonging to the same "fermentation type". Values are mM of the metabolic product per 100mM glucose fermented.

	Product \ Species	Streptococcus lactis (Simple lactic)	Lactobacillus brevis (Mixed lactic)	Propionibacterium petersoni (Propionic)	Escherichia coli (Colon group, type I)	Aerobacter aerogenes (Colon group, type II)	Eberthella typhi (Colon group, type III)	Clostridium saccharobutyricum (Butyric)	C. acetobutylicum (Butyl)	C. butylicum (Isopropyl)	Aeromonas hydrophila (Butylene-glycol)[1]
		mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM	mM/100mM
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
1	Carbon dioxide		87	51.6	50	178		196	220	297	166
2	Hydrogen				39	49		233	166	73	57
	Acids:										
3	Formic				0.9	21.2	39				
4	Acetic		17.5	54	29		26	43	25	21.2	4.6
5	Propionic			140							
6	Butyric							75	7.1	6.1	
7	Lactic	192	73		109		122				23.3
8	Succinic			11.4	15.9		10.8				3.6
	Alcohols:										
9	Ethyl		75		42	67	25		4.9		52
10	Isopropyl									15.1	
11	Butyl								47	67	
12	Glycerol		39								
13	Acetyl-methyl-carbinol					16.4			5.7		1.7
14	Butylene-glycol					63					54.7
15	Acetone								22.3		

/1/ Related to colon group.

122. OXYGEN CONSUMPTION: BLOOD FORMED ELEMENTS, MARROW, SPLEEN, LYMPH NODES, THYMUS

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Marrow, bone, erythroid cells, rabbit	Serum	9.0
2	Marrow, bone, myeloid cells, rabbit	Serum	6.0
3	Leucocytes, human, normal	Heparinized plasma	6.9
4	Leucocytes, goose	Citrated plasma glucose	4.4
5	Leucocytes, rabbit, exudate	Citrated Ringer solution	4.0-4.6
6	Leucocytes, rabbit, exudate	Serum	7.0
7	Leucocytes, rat	Serum	9.0-9.2
8	Nodes, lymph, human	Ringer glucose	3.8-5.9
9	Nodes, lymph, rat	Ringer glucose	4.4
10	Platelets, human	Citrated plasma glucose	6.2-8.4
11	Platelets, dog	Citrated plasma glucose	5.1
12	Platelets, rat	Serum	6.0
13	R B C, human	Ringer glucose	0.045
14	R B C, horse	Ringer glucose	0.06
15	R B C, rabbit	Saline	0.008
16	R B C, rabbit	Serum	0.095
17	R B C, rat	Ringer glucose	0.038
18	R B C, (nucleated), chicken	Saline; Ringer glucose	0.14
19	R B C, (nucleated), chicken	Serum	0.30
20	R B C, (nucleated), goose	Serum	0.58-1.79
21	R B C, (nucleated), turtle	Saline	0.05
22	Reticulocytes, rabbit	Ringer glucose	0.25
23	Reticulocytes, rabbit	Serum	1.75
24	Spleen, guinea pig	Saline	8.13
25	Spleen, rat	Ringer glucose	7.2-12.9
26	Spleen, rat	Serum	13.0
27	Thymus, rat	Ringer glucose	5.5-5.8
28	Tonsil, human	Ringer glucose	5.1

123. OXYGEN CONSUMPTION: EPITHELIUM AND ASSOCIATED TISSUES

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Mucosa, colon, rabbit	Ringer glucose; serum	11.1
2	Mucosa, colon, rat	Ringer glucose	3.4-14.6
3	Mucosa, duodenal, rat	Ringer glucose	8.8
4	Mucosa, gastric, human	Ringer glucose	9.6
5	Mucosa, gastric, rat	Ringer glucose	7.2
6	Mucosa, ileum, rat	Ringer glucose	3.7
7	Mucosa, intestinal, rat	Ringer glucose	9.4-23.3
8	Mucosa, jejunal, rat	Ringer glucose	12.4
9	Mucosa, uterine, rabbit	Serum	6.1
10	Skin, human, fetus	Ringer phosphate	1.8
11	Skin, human, adult	Ringer glucose	2.1
12	Skin, guinea pig	Ringer glucose	3.0
13	Skin, mouse, newborn	Ringer glucose	6.1
14	Skin, rat, newborn	Ringer glucose	3.5
15	Skin, rat, 10-36 da	Ringer glucose	4.9-3.6[1]
16	Skin, rat, 79 da, adult	Ringer glucose	1.8-1.2[1]

/1/ Range shows a decrease with age.

124. OXYGEN CONSUMPTION: GLAND TISSUES

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Adrenal, guinea pig	Serum	6.0
2	Mouse	Serum	6.0
3	Rat	Serum	10.0
4	Pancreas, cat	Ringer glucose	5.8
5	Dog	Ringer glucose	3.2
6	Guinea pig	Saline	2.7
7	Pigeon	Saline	8.7
8	Rabbit	Ringer glucose	4.6
9	Rat	Saline	3.7
10	Rat	Ringer glucose	5.2
11	Pituitary, mouse	Serum	8.0
12	Rat, young	Serum	12.0
13	Rat, anterior pituitary	Ringer glucose	5.9
14	Rat, posterior pituitary	Ringer glucose	6.6
15	Salivary gland, human	Ringer glucose	6.3
16	Cat, acetylcholine stimulation	Ringer glucose	13.6
17	Cat, eserine plus AcCh	Ringer glucose	22.7
18	Cat, resting	Ringer glucose	10.3
19	Dog	Ringer glucose	10.6
20	Guinea pig	Saline	5.0
21	Rat	Ringer glucose	11.6-16.6
22	Thyroid, calf	Ringer glucose	2.6
23	Dog	Serum	9.1
24	Dog	Ringer glucose	2.0
25	Hog	Ringer glucose	2.1
26	Rabbit	Ringer glucose, serum	11.7
27	Rat	Ringer glucose	12.5-13.0

125. OXYGEN CONSUMPTION: LUNG

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Species	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Cat	Ringer glucose	3.9
2	Guinea pig	Ringer glucose	6.1
3	Guinea pig	Saline	7.4
4	Human embryo	Ringer glucose	3.7
5	Mouse	Ringer glucose	7.3-8.0
6	Pigeon	Ringer glucose	3.6
7	Rabbit	Ringer glucose	6.7
8	Rat, adult	Saline	7.9
9	Rat, adult	Ringer glucose	4.4-7.8
10	Rat, embryo	Serum	10.0

126. OXYGEN CONSUMPTION: LIVER

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Species	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Chick embryo, 6 da	Ringer glucose	7.5
2	Chick embryo, 12 da	Ringer glucose	4.5
3	Chick embryo, 20 da	Ringer glucose	1.5
4	Cow	Ringer glucose	2.6
5	Dog	Ringer glucose	6.0
6	Guinea pig	Saline	8.1
7	Guinea pig	Ringer solution	5.0
8	Guinea pig, fatty liver	Ringer solution	7.4
9	Hen	Serum	14.5
10	Horse	Ringer glucose	2.1
11	Mouse	Ringer solution	18.7
12	Mouse	Ringer glucose	8.8-13.8
13	Rabbit	Ringer glucose	4.2-7.7
14	Rat fetus	Serum, Ringer glucose	7.1
15	Rat, young, 3-21 da	Ringer glucose	13.2
16	Rat, adult	Ringer solution	9.8-10.2
17	Rat, adult	Ringer glucose	6.5-11.6
18	Sheep	Ringer glucose	2.5

127. OXYGEN CONSUMPTION: MISCELLANEOUS TISSUES, COMPARATIVE

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Species	$-Q_{O_2}$ [1]				
		Brain Cortex	Kidney Cortex	Liver	Spleen	Lung
	(A)	(B)	(C)	(D)	(E)	(F)
1	Cat	26.9	22.7	13.2	8.4	3.9
2	Cattle	17.2	23.5	8.2	4.4	4.3
3	Dog	21.2	27.0	11.7	6.6	4.9
4	Guinea pig	27.3	31.8	13.0	11.6	8.5
5	Horse	15.7	21.5	5.4	4.2	4.4
6	Mouse	32.9	46.1	23.1	16.9	12.0
7	Rabbit	28.2	34.5	11.6	14.2	8.0
8	Rat	26.3	38.2	17.2	12.7	8.6
9	Sheep	19.7	27.5	8.5	6.9	5.4

/1/ The medium used for the determination of the $-Q_{O_2}$ values was essentially a calcium free, Ringer-phosphate solution but containing pyruvate (or lactate), fumarate, glutamate and glucose.

128. OXYGEN CONSUMPTION: MISCELLANEOUS TISSUES, IN THE PRESENCE OF VARIOUS SUBSTRATES

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue , glucose or other nutrient may be added to the medium.

	Animal and Tissue	Nutrient Added	$-Q_{O_2}$
	(A)	(B)	(C)
1	Brain[1], rat	None added	2.9
2		Glucose	10.8
3		Glutamate	8.0
4		Lactate	13.6
5		Succinate	9.5
6	Diaphragm, rat	None added	6.3[2]
7		Glucose	5.4
8		Lactate	9.4[3]
9		Pyruvate	6.3[4]
10	Heart, dog	None added	2.6
11		Glucose	2.7
12		Lactate	4.6
13		Pyruvate	6.3
14	Kidney, rat	None added	15.8[5]
15		Alanine	38
16		Butyrate	23.2
17		Glucose	23.1[6]
18		Lactate	34
19		Pyruvate	26
20	Liver, rat	None added	7.2[7]
21		Butyrate	8.1
22		Glucose	9.0
23		Lactate	10.7
24		Succinate	26
25	Skeletal muscle strips, dog	None added	1.2
26		Glucose	1.3
27		Lactate	1.7

/1/ Cerebral cortex. /2/ Value of 5.4 also reported. /3/ Value of 8.1 also reported. /4/ Value of 9.8 also reported. /5/ Value of 17.8 also reported. /6/ Value of 19.4 also reported. /7/ Value of 8.8 also reported.

129. OXYGEN CONSUMPTION: MUSCLE

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Diaphragm, dog, young	Ringer glucose	1.9
2	Diaphragm, rabbit	Ringer glucose	2.4
3	Diaphragm, rat	Saline, Ringer sol.	4.1-5.9
4	Diaphragm, rat	Serum	5.9
5	Heart, cat	Ringer glucose	2.5
6	Heart, chick embryo, 4 da	Serum	30
7	Heart, chick embryo, 6-7 da	Serum	14.9
8	Heart, dog, juvenile	Ringer glucose	4.2
9	Heart, dog	Ringer glucose	2.6
10	Heart, rat	Ringer glucose	3.8-10.4
11	Muscle, skeletal, frog, resting	Ringer glucose	0.18-0.24
12	Muscle, skeletal, frog, electrical stimulation	Ringer solution	0.79-4.24
13	Muscle, skeletal, pigeon	Saline	2.1
14	Muscle, skeletal, rat	Ringer glucose	2.3-3.1
15	Muscle, smooth, gastric, human	Ringer glucose	1.3
16	Muscle, smooth, gastric, rat	Ringer glucose	3.5
17	Muscle, smooth, intestinal, cat	Ringer glucose	1.4
18	Muscle, smooth, intestinal, frog	Ringer glucose	0.28
19	Muscle, smooth, intestinal, rabbit	Ringer glucose	2.6
20	Muscle, smooth, intestinal, rat	Saline	7.1
21	Muscle, Smooth, intestinal, rat	Ringer glucose	6.3
22	Muscle, smooth, uterine, human	Ringer glucose	0.6

130. OXYGEN CONSUMPTION: NEOPLASMS, BENIGN, AND HYPERPLASTIC TISSUE

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Goiter, colloid, resting, human	Ringer glucose	2.5-5.2
2	Goiter, hyperactive, human	Ringer glucose	12.3
3	Heart, fibroblasts[1], 1 transfer	Serum glucose	22.5
4	Heart, fibroblasts[1], 3-8 transfers	Serum glucose	12.8
5	Heart, fibroblasts[1], 3000 transfers	Serum glucose	12.0
6	Papilloma, bladder, human	Ringer glucose	8.5-13.0
7	Polyp, nasal, human	Ringer glucose	4.1- 5.0
8	Tonsil, hyperplastic, human	Ringer glucose	6.6-14.7
9	Wart, skin, human	Ringer glucose	1.5

/1/ In tissue culture, young chicken.

131. OXYGEN CONSUMPTION: NEOPLASMS, MALIGNANT

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Adenocarcinoma, mouse	Ringer glucose	6.1-26
2	Carcinoma, Flexner-Jobling, rat	Ringer solution, Ringer glucose	6.0-8.6
3	Carcinoma, various, human	Ringer glucose	2.0-7.9
4	Carcinoma, various, mouse	Ringer glucose	11.1-18.8
5	Leukocytes, human, myelogenic leukemia	Heparinized plasma	2.6
6	Leucocytes, human, lymphatic leukemia	Heparinized plasma	6.3
7	Leucocytes, human, lymphatic leukemia	Citrated plasma glucose	5.8
8	Sarcoma, Crocker, mouse	Ringer glucose	9.7-14.8
9	Sarcoma, Jensen, rat	Ringer glucose	9.2-14.4
10	Sarcoma, Rous, chick	Ringer glucose	4.6-12.1
11	Sarcoma, Rous, chick	Serum	6.0
12	Sarcoma, various, mouse	Ringer glucose	8.5-15.3
13	Tumor, spontaneous, chick	Ringer glucose	7.3-8.8

132. OXYGEN CONSUMPTION: NERVE TISSUE, INCLUDING RETINA

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Brain, chick embryo	Serum	25
2	Cerebral cortex, man	Ringer glucose	6.0-10.3
3	Cerebral cortex, cat	Ringer glucose	8.5-12.2
4	Cerebral cortex, dog	Ringer glucose	6.7
5	Cerebral cortex, guinea pig	Saline	6.9
6	Cerebral cortex, guinea pig	Saline glucose	11.7
7	Cerebral cortex, monkey	Ringer glucose	7.4-11.8
8	Cerebral cortex, mouse	Ringer solution	11.0
9	Cerebral cortex, pig, 29-60 da fetus	Ringer solution	5.5
10	Cerebral cortex, pig, 99 da fetus	Ringer solution	6.5
11	Cerebral cortex, pig, birth to adult	Ringer solution	8.5
12	Cerebral cortex, pigeon	Saline glucose	14.6
13	Cerebral cortex, rabbit	Ringer glucose	7.3-10.4
14	Cerebral cortex, rat, 5 da	Ringer glucose	6.2
15	Cerebral cortex, rat, 50 da	Ringer glucose	14.7
16	Cerebral cortex, rat, adult	Ringer glucose	8.5-17.1
17	Ganglion, celiac, rabbit	Serum	4.0
18	Ganglion, dorsal root, rat	Ringer solution	8.0
19	Ganglion, trigeminal, sheep	Ringer solution	0.3
20	Hippocampus, frog	Ringer solution	2.4
21	Hypothalamus, rat	Ringer glucose	10.4
22	Medulla, cat	Ringer glucose	3.5
23	Medulla, rat, 5 da	Ringer glucose	3.4
24	Medulla, rat, 50 da	Ringer glucose	9.0
25	Medulla, rat, adult	Ringer glucose	2.5-4.9
26	Nerve, sciatic, frog	Ringer solution	0.3
27	Nerve, trigeminal, sheep	Ringer solution	0.5
28	Retina, dog	Ringer glucose	20.8
29	Retina, frog	Ringer glucose	3.5
30	Retina, ox	Ringer glucose	10.7
31	Retina, pig	Ringer glucose	17.7
32	Retina, rat	Ringer glucose	22.0-32
33	Spinal cord, cat	Ringer glucose	1.3
34	Spinal cord, frog	Ringer glucose	2.3

133. OXYGEN CONSUMPTION; NERVE TISSUE: DOG

Values are the cu mm oxygen consumed per mg minced fresh tissue per hour[1]. Minced fresh tissue is immersed in a phosphate saline medium containing glucose. Rate varies with the medium (cf Fn 2). In general, values rise from age 1 week to a peak at 5-7 weeks. The faster rates are found in the lower portions of the neuraxis at 1 week, and in the upper parts in the adult.

	Tissue \ Age	1st Week	3rd Week	5-7th Week	Adult
	(A)	(B)	(C)	(D)	(E)
1	Cerebral cortex	0.61	0.68	1.21	1.16[2]
2	Caudate nucleus	0.73	0.96	1.39	1.36
3	Thalamus	0.76	0.97	1.24	1.01
4	Midbrain	0.91	1.11	1.28	0.92
5	Cerebellum	0.79	0.87	0.95	1.07
6	Medulla oblongata	0.96	1.03	0.85	0.69
7	Spinal cord	0.81	0.93		0.50

/1/ Since fresh nerve tissue contains approximately 75% water, values can be converted to a per mg dry weight basis by multiplying by 4. /2/ Adult dog cerebral cortex slices, average 2.3 in Ca-free Ringer-phosphate; 1.4 in complete Ringer-bicarbonate; and 4.24 in a Ca-free phosphate saline medium supplemented with pyruvate, fumarate, and glutamate.

134. ANAEROBIC GLYCOLYSIS, NERVE TISSUE: CAT, DOG

Values are the cu mm carbon dioxide liberated per mg moist weight of minced fresh tissue per hour, in the absence of oxygen. Minced fresh tissue is immersed in a bicarbonate medium with added glucose. CO_2 values represent displacement of CO_2 from bicarbonate by metabolically formed acid. 1 cu mm of carbon dioxide corresponds to 4 µg lactic acid. Individual determinations vary as much as 100%.

	Tissue \ Age	Cat[1]			Dog[1]			
		Less than 1 Week	3-7 Weeks	Adult	Less than 1 Week	3-6 Weeks	3 Months	Adult
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
1	Cerebral cortex	0.45	1.88	1.78[2]	0.46	1.17	1.95	2.25
2	Caudate nucleus	0.85	2.21	2.39	0.73	1.57	2.56	2.29
3	Thalamus	0.83	2.09	1.67	1.04	1.60	2.43	1.93
4	Corpora quadrigemina	1.05	1.61	0.60	1.16	1.48	1.57	0.85
5	Cerebellum	0.95	1.09	0.60	0.94	0.73	1.24	0.75
6	Medulla oblongata	1.37	1.03	0.34	1.44	1.18	0.61	0.30
7	Spinal cord	0.76	0.27	0.17	0.87	0.38	0.18	0.20

/1/ At one week the highest rate of glycolysis is found in the medulla, while in the adult it occurs in the caudate nucleus and cerebral cortex. In general, a slight recession from the maximum glycolysis is observed in the adult. /2/ It has been verified that the displacement of CO_2 in measurements on the adult cat cerebral cortex is due to the production of lactic acid. It is assumed that other parts of the cat brain also produce exclusively lactic acid under these conditions.

135. OXYGEN CONSUMPTION: REPRODUCTIVE TISSUES, INCLUDING GONADS AND SPERM

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Mammary gland, rat, termination of pregnancy	Ringer glucose	1.3
2	15-22 da lactation	Ringer glucose	10.0
3	2 da after weaning	Ringer glucose	5.5
4	Ovary, mouse	Serum	9.0
5	Ovary, rat	Ringer glucose	5.7
6	Prostate, rat	Ringer glucose	7.6
7	Seminal vesicles, guinea pig, Epithelium	Ringer glucose	6.1
8	Epithelium of castrate	Ringer glucose	2.8
9	Smooth muscle	Ringer glucose	1.7
10	Smooth muscle of castrate	Ringer glucose	1.4
11	Sperm, human	Ringer phosphate	0.54
12	Sperm, bull	Ringer phosphate	6.6
13	Sperm, bull	Horse serum	11.2
14	Sperm, bull	Horse serum glucose	12.8
15	Sperm, bull, epididymal	Ringer phosphate	2.6
16	Sperm, fowl, ejaculated	Ringer phosphate	2.8
17	Sperm, guinea pig	Ringer phosphate	8.0
18	Sperm, guinea pig	Serum	18.4
19	Sperm, rabbit, ejaculated	Ringer phosphate	4.4
20	Sperm, ram, ejaculated	Ringer phosphate	9.0
21	Sperm, rat	Serum	7.7
22	Testis, rabbit	Ringer glucose	7.7
23	Testis, rat	Ringer glucose	7.5-14.3
24	Testis, rat	Serum	11.0
25	Uterus, rat	Ringer glucose	7.6
26	Uterus, rat	Ringer solution	3.7
27	Uterus, rat, castrate	Ringer solution	5.2
28	Uterus, rat, castrate plus estrogen	Ringer solution	7.9

136. OXYGEN CONSUMPTION: REPRODUCTIVE TISSUES, PLACENTA, MEMBRANES, AND EMBRYO

Values are the cu mm oxygen consumed per mg dry weight of tissue per hour (oxidation quotient, $-Q_{O_2}$). Fresh tissue is immersed in a buffered medium (phosphate or bicarbonate) in a closed chamber containing oxygen at < 1 atmosphere pressure, and maintained at ±37° C. The decrease in amount of gaseous O_2, as it is used by the tissue, is measured. The minus sign preceding the symbol Q_{O_2} indicates by convention that O_2 disappears. As the rate of oxidation is limited by the amount of oxidizable nutrient available to the tissue, glucose or other nutrient may be added to the medium.

	Animal and Tissue	Medium	$-Q_{O_2}$
	(A)	(B)	(C)
1	Allantois, chick	Ringer glucose	22.3
2	Chorion, rat	Ringer glucose	13.5
3	Decidua, human	Serum	2.5
4	Embryo, chick, 0.1-1.2 g	Serum	15.9-21.4
5	Embryo, chick, 4.7 g	Serum	8.1
6	Embryo, chick, 5-6 da	Ringer solution	10.0-12.0
7	Embryo, chick, 12 da	Ringer solution	9.9
8	Embryo, chick, 19 da	Ringer solution	7.7
9	Embryo, mouse	Ringer glucose	10.4
10	Embryo, rabbit	Ringer glucose	8.5
11	Embryo, rat, 1-3 mg	Serum	10.5-14.6
12	Embryo, rat, 13-14 da	Ringer glucose	7.2-11.0
13	Placenta, mouse, 0.4 mg	Serum	7.5
14	Placenta, mouse, 10.9-13.7 mg	Serum	6.4
15	Placenta, rabbit, fetal side	Serum	5.3
16	Placenta, rabbit, uterine side	Serum	3.4
17	Placenta, rat, 20 da	Ringer solution	7.3
18	Placenta, rat	Horse serum	3.9

137. CORRELATION OF O_2 CONSUMPTION WITH BODY SIZE: INVERTEBRATES

A general form of the relation of oxygen consumption to body size: $M = bW^{\alpha}$ (M = O_2 consumption, W = body wieght, b and α = constants). All values in columns B and D, except 1B and 1D, are read from smoothed log-log plots of O_2 consumption against body weight, according to $\log M = \log b + \alpha \log W$, or against body length, if so indicated. Plotting the indicated values on double-logarithmic paper and connecting them with a straight line, approximate values for intermediate sizes may be obtained.

	Species	Body Weight (mg or g) or Length (mm)	Temperature °C	O_2 Consumption cu mm/hr	Respiratory Quotient[1]
	(A)	(B)	(C)	(D)	(E)
	Protozoa				
1	Amoeba (Chaos chaos)	0.05 mg	22.5	0.008-0.013	0.82
	Platyhelminthes				
2	Planaria (Dugesia gonocephala)	4-65 mg	20	1.1-9.8[2]	0.71
	Nematbelminthes				
3	Ascaris (Ascaris lumbricoides)	320-7760 mg	37	84-480[3]	
	Annelida				
4	Earthworm (Lumbricus spp.)	200-2500 mg	20	16.3-212[4]	
5	Manure worm (Eisenia foetida)	12-850 mg	15	2.6-37[3?]	
	Mollusca				
6	Mussel, freshwater (Anodonta cynaea)				
7	Snail, Viennese garden (Cepaea vindobonenis)	120-2650 mg[5]	20	5.1-102[4,6]	1
8	Snail, land (Helix, Helicigona, Cepaea)				
9	Snail, pond ear (Radix auricularia)	12.5-32.8 mm	23	39-600[4?]	0.90
10	Snail, pond great (Lymnaea stagnalis)	1350-5300 mg	15	60-100[2]	
11	Snail, pond great (L. stagnalis)	140-1700 mg	20	11-66[2]	
12	Snail, ramshorn (Planorbarius corneus)	1730-5770 mg	15	34-122[2]	
13	Snail, ramshorn (P. corneus)	5.8-32 mm	23	2.4-225[2,7]	0.88
14	Snail, ramshorn (Planorbis spp.)	35-500 mg	23	2.7-20.9[2]	1.00
15	Snail, river (Viviparus viviparus)	8.5-34 mm	23	8.5-120[3]	
16	Snail, river (V. fasciatus)	3.3-37 mm	23	2.3-243[3,7]	0.60
	Arthropoda, Crustacea				
17	Bug, pill (Armadillidium pallasi)	15-160 mg	21	3.2-16.2[3]	0.94
18	Bug, sow (Oniscus asellus)	6-16 mm	23	3-22[3]	0.95
19	Bug, sow (Porcellio scaber)	6-20 mm	23	4-70[2]	1.01
20	Crab, kelp (Pugettia producta)	♂2.53-329 g[8]	15	♂0.43-14.5 ml[2,9]	
21	Crayfish (Astacus astacus)				
22	Crayfish (Potamobius torrentium)				
23	Flea, water (Daphnia pulex)	0.71-1.10 mm	21	0.0198-0.075[3]	
24	Isopod, freshwater (Asellus aquaticus)	4.5-11.5 mm	20	1.6-10.1[3]	
25	Isopod, freshwater (A. aquaticus)	5-12 mm	23	1.84-11.9[3]	0.88
26	Shrimp, brine (Artemia salina)	0.35-10 mm	30	0.015-11.3[3]	
	Arthropoda, Insecta				
27	Cockroach, oriental (Blatta orientalis)	6.5-32 mm	23	6.5-800[4]	1.06
28	Mealworm, yellow (Tenebrio molitor)	20-220 mg	20	10.2-101[4]	0.70
29	Walking stick, oriental (Dixippus morosus)	8-850 mg	20	2.6-206[4]	0.86

/1/ CO_2 liberated + O_2 consumption. /2/ O_2 consumption varies as a power of body weight intermediate between 0.67 and 1.0 (cf Fn 3,4). /3/ O_2 consumption varies as the two-thirds power of body weight (i.e., $W^{0.67}$). /4/ O_2 consumption varies with body weight (i.e., $W^{1.0}$). /5/ Winter. Spring, 200-2700 mg. /6/ Winter. Spring, 24-281 cu mm/hr. /7/ Values corrected by Krywienczyk, J. /8/ ♀1.64-119 g. /9/ Note change in units: ml/hr. ♀0.17-12.7 ml/hr.

138. OXYGEN CONSUMPTION: ENDOPARASITIC HELMINTHS

	Species	Specification	Temperature °C	Cu mm O_2/mg dry substance/hr[1]	Cu mm O_2/mg dry substance/hr[2]
	(A)	(B)	(C)	(D)	(E)
1	Paramphistomum cervi	Adults	38	0.03	
2	Schistosoma mansoni	Pairs	37.5	6.0	8.7
3	S. mansoni	Males	37.5		9.1
4	S. mansoni	Females	37.5		10.7
5	Fasciola hepatica	Adults	37.5	1.94	
6	Diphyllobothrium latum	Proglottids	37	2.7	15.0
7	D. latum	Plerocercoids	22	0.34	0.67
8	Moniezia expansa	Head region	37.5		1.1
9	M. expansa	Mature progl.	37.5		0.9
10	M. expansa	Gravid progl.	37.5		0.6
11	Trichinella spiralis	Larvae	37.5	2.35	2.37
12	Strongylus equinus	Adults	38	3.3	
13	S. vulgaris	Adults	38	3.6	
14	Haemonchus contortus	Eggs (morula)	30	9.7	
15	H. contortus	Eggs (blastula)	30	10.7	
16	H. contortus	Larvae	30	12.6	
17	Ostertagia circumcincta	Adults	38	7.4	
18	Nematodirus spp	Adults	37	5.1	
19	Nippostrongylus muris	Larvae (1 day)	30	18.4	
20	N. muris	Larvae (4 days)	30	13.0	
21	N. muris	Larvae (12 days)	30	9.2	
22	N. muris	Adults	37	6.8	
23	Eustrongylides ignotus	Larvae	37	0.56[3]	
24	Syphacia obvelata	Adults	38	4.4	
25	Neoaplectana glaseri	Adults	30	12.6	
26	Heterakis spumosa	Adults	38	4.0	
27	Ascaris lumbricoides	Small	39	0.42[3]	
28	A. lumbricoides	Males	37	0.59[3]	
29	A. lumbricoides	Females	37	0.32[3]	
30	A. lumbricoides	Small	37	0.82[3]	
31	A. lumbricoides	Large	37	0.33[3]	
32	Ascaridia galli	Adults	37	2.5	

/1/ No glucose. /2/ In presence of glucose. /3/ Figures calculated from data on dry matter percentage.

139. OXYGEN CONSUMPTION: PARASITIC PROTOZOA

Data are applicable to parasitic protozoa in presence of glucose.

	Organism	Specification	Temperature °C	Cu mm O_2 per 100 million[1] per hour
	(A)	(B)	(C)	(D)
1	Strigomonas oncopelti	Culture	28	41[2]
2	S. fasciculata	Culture	28	37[2]
3	Leptomonas ctenocephali	Culture	28	27[2]
4	Leishmania tropica	Culture	32;37;28	31;45;39
5	L. brasiliensis	Culture	28;32;37	42;32;65
6	L. donovani	Culture	37;28;32;25	38;18;27;44
7	Trypanosoma lewisi	Bloodstream, old	37	69
8	T. lewisi	Bloodstream, young	37	50
9	T. cruzi	Bloodstream	28;37	44;109,124
10	T. cruzi	Culture	28;32;37	25;43;33
11	T. conorhini	Culture	28	26
12	T. pipistrelli	Culture	30	13
13	T. congolense	Bloodstream	37	153
14	T. evansi	Bloodstream	37	166
15	T. hippicum	Bloodstream	37;38	66;200
16	T. equinum	Bloodstream	37	166
17	T. equiperdum	Bloodstream	28;37	53;91,185
18	T. rhodesiense	Bloodstream	28;37	77;103,194
19	T. gambiense	Bloodstream	37	170
20	T. gambiense	Culture	28;30;37	14;38;21
21	Trichomonas foetus	Culture	28	215
22	T. hepatica	Culture	38	600
23	Plasmodium knowlesi	Rings	38	8
24	P. knowlesi	3/4-grown segmenters	38	34
25	P. inui	Rings, amoeb.	38	9
26	P. cynomolgi	Segmenters		47
27	P. cathemerium	1/4-grown	38	10
28	P. cathemerium	3/4-grown	38	25
29	P. lophurae	1/2-3/4-grown	38	18

/1/ Estimated number of organisms. /2/ Calculated from dry weight data.

140. RATES OF RESPIRATION: LEAVES

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2. Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time. Gas volumes are expressed in cu mm of gas (at S.T.P.) per gram fresh weight of plant part per hour. Unless otherwise specified, data are applicable to the mature leaf.

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
1	Barley (Hordeum vulgare)	22.5	637	628[2]	1.0
2	Bouncing bet (Saponaria officinalis)	21	418	510	0.8
3	Broadbean (Vicia faba)	21		700	
4	Carrot (Daucus carota)	22		439[3]	
5	Corn (Zea mays)[4]	25		320	
6	Curly dock (Rumex crispus)[5]	20	152-202		
7	Ivy, English (Hedera helix)	25[6]		400-780	
8	Kalanchoe (Bryophyllum sp.)	20		404	
9	Laurel, cherry (Prunus laurocerasus)	22.5	158		
10	Lettuce (Lactuca sativa)	24	25[7]		
11	Potato (Solanum tuberosum)	20	277[8]		
12	Privet (Ligustrum lucidum)	25		500-1,200	
13	Rhododendron (Rhododendron sp.)	20	25[9]		
14	Sedum (Sedum dendroideum)[10]	18	12	29	0.4
15	Snapdragon (Antirrhinum majus)	24		175	
16	Spatterdock (Nuphar advenum)	25	168		
17	Spinach (Spinacia oleracea)	30	630	625	1.0
18	Tobacco (Nicotiana tabacum)	26		400	
19	Tomato (Lycopersicon esculentum)	25	91		
20	Viburnum (Viburnum sp.)	20	109		
21	Wandering jew (Zebrina pendula)	25	38		
22	Wheat (Triticum vulgare)	22		935-1,078	
23	Yucca (Yucca gloriosa)	22.5	78		

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed. /2/ Young leaf at 25° C, 165-295. /3/ Young leaf, 1,133. /4/ Data applicable to young leaf. /5/ Recorded values represent data from two different tests; therefore, a respiratory quotient is not calculated. /6/ At 20° C, 125 cu mm CO_2 released. /7/ At 0° C, 1.5; at 4.5° C, 17.2; at 15.5° C, 51. /8/ At 23° C, 318; at 26° C, 333; at 29° C, 374. /9/ Value applicable to winter leaves. For young summer leaves, 56. /10/ Data applicable to leafy stem.

141. RATES OF RESPIRATION: ROOTS, RHIZOMES, TUBERS, BULBS

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2. Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time. Gas volumes are expressed in cu mm of gas (at S. T. P.) per gram fresh weight of plant part per hour.

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
	Roots				
1	Beet, garden (Beta vulgaris)[2]	15.5	7.5-8.1[3]		
2	Carrot (Daucus carota)	20	44[4]	42[5]	1.1
3	Corn (Zea mays)	25		486[6]	0.8-0.9
4	Pea, garden (Pisum sativum)	20		40	
5	Radish (Raphanus sativus)[2]	20	78		
6	Rutabaga (Brassica napobrassica)	22	31		
7	Sweetpotato (Ipomoea batatas)	26.5	15.2-20.2[7]		
8	Turnip (Brassica rapa)	15.5	15.7[8]		
9	Wheat (Triticum vulgare)	22		1,338[9]	
	Rhizomes				
10	Milkweed, swamp (Asclepias incarnata)	25	34		
11	Spatterdock (Nuphar advenum)	25	26		
12	Sweetflag (Acorus calamus)	25	34		
	Tubers				
13	Potato (Solanum tuberosum)	20.2	6.6[10,11]	11.9	0.5
	Bulbs				
14	Onion (Allium cepa)	21	7.1-9.6[12,13]		
15	Tulip (Tulipa sp.)	25		20	

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed. /2/ Data applicable to root slices. /3/ At 0° C, 2.5; at 4.5° C, 4.3. /4/ At 0° C, 2; at 4.5° C, 3.3; at 15.5° C, 8.6. /5/ At 25° C, 36-43. /6/ Value applicable to primary root tip, 3 days after germination. For adventitious root portions (root tips not included), 2 weeks after germination, 82. /7/ At 4.5° C, 2-3. /8/ At 0° C, 0.2; at 4.5° C, 1.3. /9/ Value applicable to root tip. For rootlet, in growth zone, 1,200; for rootlet, in root hair zone, 301-625. /10/ At 15° C, 2-3. /11/ Immature tuber at 20° C, 16.8. /12/ At 0° C, 2.0; at 10° C, 4. /13/ At 25° C, 9 cu mm O_2 absorbed.

142. RATES OF RESPIRATION: SEEDS

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2. Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time. Gas volumes are expressed in cu mm of gas (at S.T.P.) per gram fresh weight of seeds per hour. Unless otherwise specified, data are applicable to seeds with imbibed water.

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
1	Apricot (Prunus armeniaca)	20		70	
2	Barley (Hordeum distichum)	29	74[2]	73	1.0
3	Broadbean (Vicia faba)[3]	21	456		
4	Cherry, sour (Prunus cerasus)	20		63	
5	Hawthorn (Crataegus sp.)	20		42	
6	Juniper, common (Juniperus communis)	25		91[4]	
7	Oat (Avena sativa)[5]	20	0.001		
8	Pea, garden (Pisum sativum)[5]	24	141[6]		
9	Peach (Prunus persica)	20		56	
10	Plum (P. domestica)	20		49	
11	Pumpkin (Cucurbita pepo)[3]		423		
12	Rye (Secale spp.)[5]	20	0.001		
13	Sorghum (Sorghum vulgare)	20	0.002[7]		
14	Wheat (Triticum vulgare)[5]	20[8]	0.002[9]		

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed. /2/ Air dry seeds at 20° C, 0.001./3/ Data applicable to germinating seeds. /4/ Air dry seeds at 25° C, 0.7. /5/ Data applicable to air dry seeds. /6/ Air dry seeds at 15° C, 0; freshly harvested at 15° C, 101. /7/ Air dry seeds, 0.0001. /8/ Germinating seeds at 16.5° C, 108 cu mm O_2 absorbed. /9/ Germinating seeds at 16.5° C, 58.

143. RATES OF RESPIRATION: FRUITS

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2. Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time. Gas volumes are expressed in cu mm of gas (at S.T.P.) per gram fresh weight of the fruit per hour. Unless otherwise specified, data are applicable to the mature fruit.

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
1	Apple (Pyrus malus)	27	9[2]	10[2]	0.9
2	Avocado (Persea gratissima)	15	35-90	40-105	0.9
3	Banana (Musa paridisima sapientum)[3]	20		55[4]	
4	Cucumber (Cucumis sativus)	24	21		1.0
5	Lemon (Citrus limonia)[5]	15	4.1-4.6	5.7-6.6	0.7
6	Orange, sweet (C. sinensis)	21		12.5	
7	Papaya (Carica papaya)	25	41[6]		
8	Peach (Prunus persica)	21		27	
9	Pear (Pyrus communis)	20	13		
10	Pepper (Capsicum frutescens)	24	38		1.1
11	Strawberry (Fragaria vesca)	20	59[7]	180	0.2
12	Tomato (Lycospericon esculentum)	15-17	9.9[8]	11.5[8]	0.9

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed. /2/ Immature fruit: CO_2, 35; O_2, 50. /3/ Data applicable to yellow fruit. /4/ For overripe fruit, 59; immature, 77. For CO_2 released: overripe fruit, 60; immature, 76. /5/ Data applicable to immature fruit. /6/ Immature fruit, 18.8; yellow, 28. /7/ Immature fruit, 22. /8/ Immature fruit: CO_2, 12-87; O_2, 20-92.

144. RATES OF RESPIRATION: MOSSES, FERNS

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2. Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time. Gas volumes are expressed in cu mm of gas, (at S.T.P.) per gram dry weight (unless otherwise specified) of plant material per hour.

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
	Mosses and Moss Allies (Bryophyta)				
1	Chiloscyphus fragilis	25		600-1,000	
2	Fontinalis antipyretica	25		700-1,400	
3	Hypnum cupressiforme			140[2]	
4	Riccia fluitans	25		2,500-30,000	
5	Sphagnum cuspidatum[3]		1,220	1,220	1.0
6	S. cuspidatum[4]		2,290	2,430	0.9
	Ferns and Fern Allies (Pteridophyta)[5]				
7	Club-moss, small (Selaginella martensii)	25	2,500		
8	Fern, bracken (Eupteris aquiliana)	20	6,100		
9	Fern, Hart's-tongue (Phyllitis scolopendrium)[6]	16		257[7]	
10	Fern, Hart's-tongue (P. scolopendrium)[8]	16		122[7]	
11	Fern, polypody (Polypodium vulgare)[9]	19.5	175[7]	164[7]	1.1
12	Fern, polypody (P. vulgare)[10]	19.5	96[7]	105[7]	0.9
13	Fern, shield (Drypteris austriaca)	20	2,800[7]		
14	Horsetail (Equisetum telmateia)[11]	20	52[7]	67[7]	0.8
15	Horsetail (E. telmateia)[12]	20	93[7]	112[7]	0.8

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed. /2/ Value applicable to air-dry conditions. /3/ Data applicable to dry habitat. /4/ Data applicable to wet habitat. /5/ Data applicable to leaves unless otherwise specified. /6/ Data applicable to mature leaf. /7/ Value calculated on wet weight basis. /8/ Data applicable to young leaf. /9/ Data applicable to leaf with spores. /10/ Data applicable to sterile leaf. /11/ Data applicable to basal stalks. /12/ Data applicable to fruiting tips.

145. RATES OF RESPIRATION: FUNGI, LICHENS

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2. Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time. Gas volumes are expressed in cu mm of gas (at S.T.P.) per gram dry weight (unless otherwise specified) of plant material per hour.

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
	Fungi				
1	Agaricus campestris[2]	14	71[3,4]	129[3]	0.6
2	Aspergillus clavatus	23-25[5]	5,610	3,230	1.7
3	A. niger	25[5]		15,000-20,000	
4	Blastomyces dermatitidis[6]	20		2,400	
5	B. dermatitidis[7]	20		14,150	
6	Daedalea quercina	40[8]		9,400[3]	
7	Fusarium sp.	30[8]		40,000	
8	Myrothecium verrucaria[9]	30		58,000	
9	M. verrucaria[10]	30		108,000	
10	Neurospora tetrasperma[11]	25	9,620-19,600	9,620-19,600	1.0
11	N. tetrasperma [12]	25		250-590	
12	Penicillium notatum	19.8-24.2[13]		15,000	
13	Phycomyces blakesleeanus	20[5]	25,000-30,000		
14	Physarum polycephalum[14]	22		400	0.8
15	P. polycephalum[15]	22		1,400	
16	Pilobolus kleinii	26[6]		2,600	
17	Polyporus versicolor	25	3,300[3]		
18	Saccharomyces sp.	28[5]		40,000-80,000	
19	Thelephora tremelloides	9		940[3]	
20	Zygosaccharomyces sp.	28[5]		60,000	
	Lichens				
21	Cladonia rangiferina	10	116	145	0.8
22	Peltigera canina	21	70-140[3]		

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed. /2/ Also known as Psalliota campestris. /3/ Calculated on wet weight basis. /4/ At 25°C, 4,800; cf. Fn 3. /5/ Glucose in media. /6/ Data applicable to young mycelium form. /7/ Data applicable to yeast form. /8/ Endogenous. /9/ Data applicable to a 48-hour culture. /10/ Data applicable to a 28-hour culture. /11/ Data applicable to anaerobic respiration of germinating ascospores. /12/ Data applicable to anaerobic respiration of dormant ascospores. /13/ Lactose in media. /14/ Data applicable to large mass plasmodium (protoplasmic mass). /15/ Data applicable to small mass plasmodium.

146. RATES OF RESPIRATION: ALGAE

Respiration in plant tissue, as in animal tissue, involves both consumption of O_2 and evolution of CO_2. Gaseous exchange is measured by placing the tissue in a calibrated chamber containing a gas mixture (O_2 and CO_2) of known composition, replenished if necessary, and determining the alteration in composition of the mixture after a suitable time. Gas volumes are expressed in cu mm of gas (at S.T.P.) per gram dry weight of plant material per hour.

	Species	Temperature	Carbon Dioxide Released	Oxygen Absorbed	Respiratory Quotient[1]
		°C	cu mm/g/hr	cu mm/g/hr	
	(A)	(B)	(C)	(D)	(E)
	Cyanophyta (Blue-green)				
1	Anabaena sp.	25		4,500	
	Chlorophyta (Green)				
2	Chlorella ellipsoidea	25		1,300	
3	C. pyrenoidosa	25[2,3]	1,600-12,800	1,400-11,200	1.1
4	Cladophora arcta	12		900	
5	Enteromorpha linza	25		1,100	
6	Nitella clavata[4]	23		20,000-30,000	
7	Scenedesmus obliquus	25[2]		500	
8	Spirogyra sp.[5]	35	260-610	1,260-2,100	0.2-0.3
9	Spirogyra sp.[6]	35	1,530-2,190	1,400-2,100	1.0
10	Ulva lactuca	18.1	472	493	0.9
11	U. lactuca	25		2,600	
	Phaeophyta (Brown)				
12	Ascophyllum nodosum			2,940	
13	Fucus serratus	18.3	165	307	0.5
14	Laminaria phyllitis			900	
	Rhodophyta (Red)				
15	Chondrus crispus	14		400	
16	Gigartina teedii	11.6		440	
17	Polysiphonia violacea	11.1	1,031	891	1.2

/1/ Refers to the ratio of the volume of CO_2 released to the volume of O_2 absorbed. /2/ Endogenous. /3/ In glucose solution: CO_2, 23,000; O_2, 19,000. /4/ Data applicable to plant tips. /5/ Data applicable to sexual (conjugating) stage. /6/ Data applicable to vegetative stage.

147. OXYGEN CONSUMPTION: BACTERIAL SUSPENSIONS

Data are applicable to bacterial supensions in the presence of glucose, unless otherwise specified. The oxidation quotient, $-Q_{O_2}$, is the cu mm of O_2 consumed per mg dry weight per hour.

	Organism	Age of cell, hr	Temp °C	$-Q_{O_2}$
	(A)	(B)	(C)	(D)
1	Azotobacter chroococcum	36	22	2000-10,000
2	Aerobacter aerogenes	17;48	36;30	47,50
3	Bacillus cereus (short)	18	30?	42-86
4	B. Cereus (filamentous)	18	30?	3-49
5	B. Subtilis	6-8	37	170
6	B. Subtilis, spores	98-147	32	10
7	Corynebacterium sp.	48-96	30?	67
8	Escherichia coli	20	40;32	200;272
9	Lactobacillus bulgaricus	8	37;45	34;55
10	Leuconostoc citrovorum	16	38	8
11	Micrococcus luteus	30-34	35	15
12	M. flavus	30-34	35	8
13	M. auranticus	30-34	35	14
14	M. cinnebareus	30-34	35	32
15	M. Fruendenreichii	30-34	35	20
16	Mycobacterium phlei	84	38	28
17	M. smegmatis	84	38	23
18	M. stercoris	84	38	15
19	M. sp. Karlinski	84	38	22
20	M. ranae	84	38	32
21	M. leprous kedrowsky	84	38	8
22	M. butyricum	84	38	13
23	M. tuberculosis hominis	252	38	4
24	M. tuberculosis avian	84	37	1
25	Pneumococcus, Type I	18	37	27
26	Pseudomonas fluorescens	20	26	58
27	Streptococcus faecalis, B33A	18	38	106
28	S. Faecalis, 10C1	15	37	57-80
29	S. Faecalis, Lancefield D	12-15	37	7
30	S. pyogenes, C203M	4	37.5	57-163[1,2]
31	S. pyogenes, C203S	4	37.5	99-113[1,3]
32	S. thermophilus, C3	8	37;50	4;5
33	S. thermophilus, MC	8	37;50	9;10
34	Streptomyces coelicolor	72		35

/1/ In a medium containing yeast extract. /2/ In a medium composed of saline and glucose, 17-24. /3/ In a medium composed of saline and glucose, 25-42.

148. BASAL METABOLISM: MAN

Values (col. B,D) are smoothed means of basal Calories per sq m per hr from the three largest and most authoritative sets of original data, representing a total of 4016 measurements. The three sets of data used are: (1) The Mayo Foundation Standards of Boothby, Berkson and Dunn, based upon 639 males and 828 females;(2) The British measurements of Robertson and Reid, based upon 987 males and 1323 females; (3) The Carnegie Nutrition Laboratory Data of Harris and Benedict, based upon 136 males and 103 females. The height-weight formula of DuBois and DuBois was used in computing the sq m of body surface area: $SA = 0.007184 \times W^{0.425} \times S^{0.725}$, where SA is the surface area in square meters, W is the body weight in kilograms and S is the height in centimeters. Ranges are calculated from an average coefficient of variation[1] of 6.9% and represent estimate "b" of the 95% range. Somewhat higher values are to be expected on first tests (i.e., on persons not accustomed to the procedures). For comparison of these standards with previous American and other important standards, see table 149.

Line No.	Age yr	Males		Females	
		Value	Range	Value	Range
		Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr
	(A)	(B)	(C)	(D)	(E)
1	Three	60.1	51.8-68.3	54.5	47.0-62.0
2	Four	57.9	49.9-65.9	53.9	46.5-61.3
3	Five	56.3	48.5-64.1	53.0	45.7-60.3
4	Six	54.0	46.5-61.5	51.2	44.1-58.3
5	Seven	52.3	45.1-59.5	49.7	42.8-56.6
6	Eight	50.8	43.8-57.8	48.0	41.4-54.6
7	Nine	49.5	42.7-56.3	46.2	39.8-52.6
8	Ten	47.7	41.1-54.3	44.9	38.7-51.1
9	Eleven	46.5	40.1-52.9	44.1	38.0-50.2
10	Twelve	45.3	39.0-51.6	42.0	36.2-47.8
11	Thirteen	44.5	38.4-50.6	40.5	34.9-46.1
12	Fourteen	43.8	37.8-49.8	39.2	33.8-44.6
13	Fifteen	43.7	37.7-49.7	38.3	33.0-43.6
14	Sixteen	42.9	37.0-48.8	37.7	32.5-42.9
15	Seventeen	41.9	36.1-47.7	36.2	31.2-41.2
16	Eighteen	40.5	34.9-46.1	35.7	30.8-40.6
17	Nineteen	40.1	34.6-45.6	35.4	30.5-40.3
18	Twenty	39.8	34.3-45.3	35.3	30.4-40.2
19	Twenty-one	39.4	34.0-44.8	35.2	30.3-40.1
20	Twenty-two	39.2	33.8-44.6	35.2	30.3-40.1
21	Twenty-three	39.0	33.6-44.4	35.2	30.3-40.1
22	Twenty-four	38.7	33.4-44.0	35.1	30.3-39.9
23	Twenty-five	38.4	33.1-43.7	35.1	30.3-39.9
24	Twenty-six	38.2	32.9-43.5	35.0	30.2-39.8
25	Twenty-seven	38.0	32.8-43.2	35.0	30.2-39.8
26	Twenty-eight	37.8	32.6-43.0	35.0	30.2-39.8
27	Twenty-nine	37.7	32.5-42.9	35.0	30.2-39.8
28	Thirty	37.6	32.4-42.8	35.0	30.2-39.8
29	Thirty-one	37.4	32.2-42.6	35.0	30.2-39.8
30	Thirty-two	37.2	32.1-42.3	34.9	30.1-39.7
31	Thirty-three	37.1	32.0-42.2	34.9	30.1-39.7
32	Thirty-four	37.0	31.9-42.1	34.9	30.1-39.7
33	Thirty-five	36.9	31.8-42.0	34.8	30.0-39.6
34	Thirty-six	36.8	31.7-41.9	34.7	29.9-39.5
35	Thirty-seven	36.7	31.6-41.8	34.6	29.8-39.4
36	Thirty-eight	36.7	31.6-41.8	34.5	29.7-39.3
37	Thirty-nine	36.6	31.5-41.7	34.4	29.7-39.1
38	Forty	36.5	31.5-41.5	34.3	29.6-39.0
39	Forty-five	36.3	31.3-41.3	33.9	29.2-38.6
40	Fifty	36.0	31.0-40.0	33.4	28.8-38.0
41	Fifty-five	35.4	30.5-40.3	32.9	28.4-37.4
42	Sixty	34.8	30.0-39.6	32.4	27.9-36.9
43	Sixty-five	34.0	29.3-38.7	31.8	27.4-36.2
44	Seventy	33.1	28.5-37.7	31.3	27.0-35.6
45	Seventy-five[2]	31.8	27.4-36.2	31.1[3]	26.8-35.4

/1/ Coefficient of variation = 6.9 = average of values from five sources (cf. bibliography). /2/ Data applicable to ages seventy-five and above. /3/ Value (and range) extrapolated from smoothed curve.

149. COMPARISON OF STANDARDS OF BASAL METABOLISM: MAN

Column F is the standard commonly employed heretofore in America. The underlying measurements include many first tests (on persons unaccustomed to the procedures). Values are accordingly high -- the highest of the standards. Values in column D, the British Standard, are based on the lowest of repeated measurements on trained persons under rigorously basal conditions. Measures taken to eliminate metabolism-raising influences have been particularly effective with adults, yielding lower values than those in any other column. Values in column E are based on measurements on well trained children and are generally the low-

Line No.	Age yr	Males				
		Boothby[1] 1952	Fleisch[2] 1951	Robertson and Reid[3] 1952	Lewis Duval and Iliff[4] 1943	Boothby Berkson and Dunn[5] 1936
		Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr
	(A)	(B)	(C)	(D)	(E)	(F)
1	One		53.0			
2	Two		52.4		56.9	
3	Three	60.1	51.3	60.1	54.5	
4	Four	57.9	50.3	57.9	52.6	
5	Five	56.3	49.3	56.3	51.0	
6	Six	54.0	48.3	54.2	49.6	53.0
7	Seven	52.3	47.3	52.1	48.2	52.4
8	Eight	50.8	46.3	50.1	46.6	51.5
9	Nine	49.5	45.2	48.2	45.0	49.9
10	Ten	47.7	44.0	46.6	43.6	48.0
11	Eleven	46.5	43.0	45.1	42.2	47.2
12	Twelve	45.3	42.5	43.8	41.5	46.8
13	Thirteen	44.5	42.3	42.7	41.4	46.5
14	Fourteen	43.8	42.1	41.8	41.1	46.4
15	Fifteen	42.9	41.8	41.0	40.5	46.1
16	Sixteen	42.0	41.4	40.3		45.5
17	Seventeen	41.5	40.8	39.7		44.4
18	Eighteen	40.8	40.0	39.2		42.9
19	Nineteen	40.5	39.2	38.8		42.2
20	Twenty	39.9	38.6	38.4		41.6
21	Twenty-five	38.4	37.5	37.1		40.3
22	Thirty	37.6	36.8	36.4		39.6
23	Thirty-five	36.9	36.5	35.9		38.9
24	Forty	36.5	36.3	35.5		38.3
25	Forty-five	36.3	36.2	34.3[6]		37.6
26	Fifty	36.0	35.8	33.9[6]		37.0
27	Fifty-five	35.4	35.4	33.6[6]		36.3
28	Sixty	34.8	34.9	33.2[6]		35.7[8]
29	Sixty-five	34.0	34.4	32.8[6]		35.1[8]
30	Seventy	33.1	33.8	32.6[6]		34.5[8]
31	Seventy-five[7]	31.8	33.2	32.0		33.4[8]

/1/ Present H. B. D. values (cf. table 148) based on values in cols. D, F and values from Harris and Benedict, 1919. /2/ Based on values from 24 reports in the literature, including those in cols. E,F, of this table and values from Harris and Benedict, 1919. /3/ The British Standard. These values constitute part of the basis for those in col. B.

149. COMPARISON OF STANDARDS OF BASAL METABOLISM: MAN

est of those given for children. Adult values in columns B and C are so similar that either standard can be used safely in clinical medicine. For children, choice between columns E or C and columns B or D will depend on the experience of the testing laboratory. Some laboratories (even some technicians) tend to find higher basal values and some laboratories, lower. Each laboratory may accordingly develop its own standard. A variation of as much as 14% above or below the standard may occur in healthy persons (estimate "b", "d" of the ordinary range).

Line No.	Age yr	Females				
		Boothby[1] 1952	Fleisch[2] 1951	Robertson and Reid[3] 1952	Lewis Duval and Iliff[4] 1943	Boothby Berkson and Dunn[5] 1936
		Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr	Cal/sq m/hr
	(A)	(B)	(C)	(D)	(E)	(F)
1	One		53.0			
2	Two		52.4		52.9	
3	Three	54.5	51.2	54.5	51.3	
4	Four	53.9	49.8	53.9	49.9	
5	Five	53.0	48.4	53.0	48.4	
6	Six	51.2	47.0	51.8	46.9	50.5
7	Seven	49.7	45.4	50.2	45.5	48.5
8	Eight	48.0	43.8	48.4	44.0	46.7
9	Nine	46.2	42.8	46.4	42.7	46.1
10	Ten	44.9	42.5	44.3	41.4	45.7
11	Eleven	43.5	42.0	42.4	40.4	45.1
12	Twelve	42.0	41.3	40.6	39.7	43.9
13	Thirteen	40.5	40.3	39.1	38.4	42.5
14	Fourteen	39.2	39.2	37.8	36.8	41.1
15	Fifteen	38.3	37.9	36.8	35.2	39.7
16	Sixteen	37.2	36.9	36.0		38.6
17	Seventeen	36.4	36.3	35.3		37.6
18	Eighteen	35.8	35.9	34.9		37.0
19	Nineteen	35.4	35.5	34.5		36.6
20	Twenty	35.3	35.3	34.3		36.3
21	Twenty-five	35.1	35.2	34.0		36.0
22	Thirty	35.0	35.1	34.1		35.8
23	Thirty-five	34.8	35.0	33.5		35.7
24	Forty	34.3	34.9	32.6		35.5
25	Forty-five	33.9	34.5	32.4[6]		35.3
26	Fifty	33.4	33.9	32.1[6]		34.4
27	Fifty-five	32.9	33.3	31.8[6]		33.4
28	Sixty	32.4	32.7	31.4[6]		32.8
29	Sixty-five	31.8	32.2	31.2[6]		32.4
30	Seventy	31.3	31.7	30.8[6]		32.2
31	Seventy-five[7]	31.1[9]	31.3	30.5[9]		32.0[8]

/4/ These values constitute part of the basis for those in Col. C. /5/ These values constitute part of the basis for those in cols. B and C. /6/ Interpolated. Original data given for pentades 40-44, 45-49, etc. /7/ Values are for age 75 or over. /8/ Extrapolated by authors. /9/ Extrapolated.

150. BASAL METABOLISM: VERTEBRATES

Values are for adults.

	Species	Body Weight	Body Surface[1]	Basal Metabolism Calories/day[2]		
		kg	sq m	Total[3]	per sq m	per $kg^{0.75}$
	(A)	(B)	(C)	(D)	(E)	(F)
1	Man ♂	65	1.83	1667	910	73
2	Man ♀	57	1.63	1347	828	65
3	Baboon	6.23	0.421	300	761	77
4	Cattle	366	4.56	5678	1245	68
5	Chicken	2.58	0.163	138	740	68
6	Chimpanzee	38	1.13	1111	986	73
7	Dog	14.9	0.652	542	831	72
8	Goat	36	1.09	747	683	51
9	Goose	5.0	0.292	276	945	82
10	Guinea pig	0.758	0.0687	48	700	59
11	Monkey, rhesus	3.22	0.257	156	608	65
12	Mouse	0.0285	0.00704	5.20	739	75
13	Pig	186	2.67	2647	993	52
14	Rabbit	3.5	0.198	160	809	62
15	Rat	0.300	0.0384	26	686	65
16	Sheep	30	0.805	692	860	55

/1/ Surface area calculated in sq cm from following equations in which W = body weight in grams: man (♂or♀), $3.81\ W^{0.425} \times H^{0.725}$ (where H = height in cm); baboon, $11.7\ W^{0.667}$; cattle, $15.82\ W^{0.625}$; chicken, $9.85\ W^{0.67}$ or $5.86\ W^{0.5} \times L^{0.6}$ (where L = rump to shoulder length in cm); chimpanzee, $10\ W^{0.667}$ (assumed); dog, $11.2\ W^{0.667}$; goat, $10\ W^{0.667}$ (assumed); goose, $10\ W^{0.67}$ (assumed); guinea pig, $9.85\ W^{0.64}$; monkey, rhesus, $11.7\ W^{0.667}$; mouse, $15.18\ W^{0.458}$; pig, $12.24\ W^{0.633}$; rabbit, $56.33\ W^{0.436}$; rat, $12.54\ W^{0.60}$; sheep, $8.5\ W^{0.667}$ /2/ In kilocalories. /3/ For entire organism.

151. BASAL AND RESTING ENERGY METABOLISM: BEEF CATTLE

"Resting metabolism"[1] refers to heat production when the animal is at rest in a recumbent position, before the morning feeding and under customary farm conditions. The measurements are not taken in a strictly thermo-neutral environment nor in the post-absorptive conditions. The resting metabolism, as thus defined, is considerably above the basal metabolism, the exact value depending on the nature of the diet, the time after feeding, and the environmental temperature.

Hereford Breed

	Approximate Age	Body Weight	Body Surface Area[2]	Resting Metabolism[1,3,4]		Oxygen Consumption[5]	Basal Metabolism[3,6,7]		Oxygen Consumption[5]
		kg	sq m	Cal/kg/day	Cal/sq m/day	liters/kg/day	Cal/kg/day	Cal/sq m/day	liters/kg/day
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
	Males								
1	1.0 mo	40	1.02	53.9	2104	11.2			
2	1.3 mo	50	1.16	49.6	2137	10.3			
3	1.6 mo	60	1.29	46.4	2165	9.6			
4	1.8 mo	70	1.40	43.8	2188	9.1			
5	2.0 mo	80	1.51	41.7	2208	8.6			
6	2.5 mo	90	1.61	39.9	2227	8.3			
7	3.0 mo	100	1.71	38.4	2243	8.0			
8	6.0 mo	150	2.15	33.0	2304	6.9			
9	7.0 mo	200	2.53	29.7	2352	6.2			
10	9.0 mo	250	2.86	27.4	2389	5.7			
11	11.0 mo	300	3.17	25.6	2420	5.3			
12	1.1 yr	350	3.46	24.2	2444	5.0			
13	1.3 yr	400	3.72	23.0	2471	4.8			
14	1.5 yr	450	3.97	22.0	2491	4.6			
15	1.7 yr	500	4.21	21.2	2513	4.4			
	Females								
16		40	1.02	61.8	2411	12.8			
17		50	1.16	55.7	2398	11.5			
18	1.8 mo	60	1.29	51.1	2386	10.6			
19	2.5 mo	70	1.40	47.6	2376	9.9			
20	3.0 mo	80	1.51	44.7	2368	9.3			
21	4.0 mo	90	1.61	42.3	2361	8.8			
22	5.0 mo	100	1.71	40.3	2354	8.4			
23	6.5 mo	150	2.15	33.4	2326	6.9	22.2	1551	4.6
24	9.0 mo	200	2.53	29.2	2310	6.1	19.9	1575	4.1
25	11.0 mo	250	2.86	26.3	2296	5.5	18.2	1594	3.8
26	1.2 yr	300	3.17	24.1	2286	5.0	17.0	1610	3.5
27	1.4 yr	350	3.46	22.5	2275	4.7	16.0	1620	3.3
28	1.7 yr	400	3.72	21.1	2270	4.4	15.2	1635	3.2
29	2.0 yr	450	3.97	20.0	2136	4.1	14.5	1646	3.0

/1/ For techniques employed and underlying assumptions see Mo. Agr. Exp. Sta. Res. Bull. 404. /2/ Surface area based on equation, Surface Area in sq. meters = $0.13\ (\text{weight in kg})^{0.56}$. /3/ In kilocalories. /4/ For males, data based on equation, $Y = 211\ X^{0.63}$; for females, $Y = 345\ X^{0.53}$; where Y = resting metabolism in Calories/day and X = body weight in kg. /5/ Standard temperature and pressure. /6/ For females, data based on equation, $Y = 154\ X^{0.61}$, where Y = basal metabolism in Calories/day and X = body weight in kg. /7/ The "basal metabolism" is calculated from the observed oxygen consumption of the resting animal, measured at frequent intervals after feeding until it becomes roughly constant, i.e., until after the "specific dynamic effect" has ended (about 2 days after the last feeding).

152. RESTING ENERGY METABOLISM: DAIRY CATTLE

"Resting metabolism"[1] refers to heat production when the animal is at rest in a recumbent position, before the morning feeding and under customary farm conditions. The measurements are not taken in a strictly thermo-neutral environment nor in the post-absorptive condition. The resting metabolism, as thus defined, is considerably above the basal metabolism, the exact value depending on the nature of the diet, the time after feeding, and the environmental temperature.

Holstein and Jersey Breeds, Females Only

	Approximate Age		Body Weight	Body Surface Area[2]	Resting Metabolism[3,4]		Oxygen Consumption[5]	Resting Metabolism[3,4]		Oxygen Consumption[5]
			kg	sq m	Cal/kg/day	Cal/sq m/day	liters/kg/day	Cal/kg/day	Cal/sq m/day	liters/kg/day
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	Holstein Females	Jersey Females	Holstein and Jersey Females		Holstein Females			Jersey Females		
1		0.5 mo	25	0.92				52.1	1420	10.8
2	0.4 mo		40	1.17	46.9	1600	9.7			
3	1.1 mo	1.6 mo	50	1.34	45.1	1700	9.3	47.3	1770	9.8
4	3.8 mo	5.5 mo	100	1.92	39.7	2060	8.2	39.1	2050	8.0
5	6.0 mo	8.1 mo	150	2.45	34.4	2100	7.1	32.8	2010	6.8
6	8.2 mo	1.0 yr	200	2.89	30.6	2130	6.3	29.0	1990	6.0
7	11.5 mo	1.3 yr	250	3.28	28.0	2120	5.8	26.2	2020	5.4
8	1.2 yr	1.6 yr	300	3.60	26.0	2170	5.4	24.1	2010	5.0
9	1.4 yr	1.9 yr	350	4.02	24.4	2140	5.1	22.6	1960	4.7
10	1.6 yr	2.1 yr	400	4.33	23.1	2160	4.8	21.2	1940	4.4
11	1.8 yr		450	4.60	22.1	2160	4.6	20.2		4.2
12	2.0 yr		500	5.01	21.1	2180	4.4	19.3		4.0
13			550		20.3		4.2			
14			600		19.7		4.1			

/1/ For techniques employed and underlying assumptions see Mo. Agr. Exp. Sta. Res. Bull. 335 and 350. /2/ Surface area based on equation, Surface Area in sq. meters = 0.15 (weight in kg)$^{0.56}$. See Mo. Agr. Exp. Res. Bull. 89, p. 10. /3/ In kilocalories. /4/ For Holstein females, up to approximately 150 kg, data based on equation, $Y = 93\ X^{0.81}$, over 150 kg, $Y = 259\ X^{0.60}$; for Jersey females, up to 100 kg, $Y = 99.3\ X^{0.84}$, over 100 kg, $Y = 295\ X^{0.56}$, where Y = resting metabolism in Calories/day and X = body weight in kg. /5/ Standard temperature and pressure.

153. RESTING ENERGY METABOLISM: GOATS

"Resting metabolism"[1] refers to heat production when the animal is at rest in a recumbent position, although neither in a strictly thermo-neutral environment nor in a post-absorptive condition. It is measured before the morning feeding under customary farm conditions. The resting metabolism, as thus defined, is considerably greater than the basal metabolism, the exact value depending on the nature of the diet, the time after feeding, and the environmental temperature.

Toggenburg and Angora Goats[2]

	Body Weight (♂ or ♀) kg (A)	Resting Metabolism[3,4] Cal/kg/day (B)		Body Weight (♂ or ♀) kg (A)	Resting Metabolism[3,4] Cal/kg/day (B)		Body Weight (♂ or ♀) kg (A)	Resting Metabolism[3,4] Cal/kg/day (B)
1	2	♂132; ♀124	9	18	♂65; ♀54	16	35	♂52; ♀44
2	4	♂106; ♀97	10	20	♂63; ♀54	17	40	♂♂50; ♀42
3	6	♂93; ♀84				18	45	♂48; ♀40
4	8	♂85; ♀75	11	22	♂61; ♀52	19	50	♂47; ♀39
5	10	♂79; ♀70	12	24	♂59; ♀51	20	55	♂45; ♀38
			13	26	♂58; ♀49			
6	12	♂74; ♀65	14	28	♂56; ♀48	21	60	♂44; ♀36
7	14	♂71; ♀62	15	30	♂55; ♀47	22	65	♂43; ♀35
8	16	♂68; ♀59				23	70	♂42; ♀34

/1/ For techniques employed and underlying assumptions see Mo. Agr. Exp. Sta. Res. Bull. 291. /2/ Sixteen Toggenburg and six Angora goats. /3/ In kilocalories. /4/ For males data based on equation, $Y = 166\ X^{0.676}$, and for females, $Y = 160\ X^{0.638}$, where Y = resting metabolism in Cal/day and X = body weight in kg.

154. BASAL AND RESTING ENERGY METABOLISM: GUINEA PIGS

Basal metabolism[1] is calculated from the 24-48 hour fasting oxygen consumption of the resting animal. Resting metabolism[1] is affected by the calorigenic action of the feed. Measurements were made at about 30°, considered to be thermoneutral for the animal. Values are from smoothed plotted curves based on tabular data and curves in the original source publication.

	Approximate Age (A) Males	Approximate Age (B) Females	Body Weight kg (C)	Surface Area[2] sq m (D)	Resting Metabolism[1] Cal/kg/day (E) Males	(F) Females	Cal/sq m/day (G) Males	(H) Females	Approximate Age (I) Males	(J) Females	Body Weight[3] kg (K)	Surface Area[2] sq m (L)	Basal Metabolism[1] Cal/kg/day (M) Males	(N) Females	Cal/sq m/day (O) Males	(P) Females
			Males & Females								Males & Females					
1	Birth		0.080	0.0164	154	160	751	781								
2	2 da		0.100	0.0188	150	154	798	819								
3	19 da		0.150	0.0243	122	128	753	790	22		0.150	0.0243	117[4]	120[4]	722	741
4	30 da		0.200	0.0293	114	118	778	805	34		0.200	0.0293	108	112	737	765
5	75 da	80 da	0.400	0.0456	91	94	798	825	82	87	0.400	0.0456	86	90	754	789
6	137 da	154 da	0.600	0.0591	75	79	761	802	145	170	0.600	0.0591	71	74	721	751
7	290 da	270 da	0.800	0.0710	63	68	710	766			0.800	0.0710	60	63	676	710
8			0.900	0.0766	57	66	670	775			0.900	0.0766	57		670	
9			1.000	0.0819	54	63	659	769			1.000	0.0819	54		659	

/1/ See source publication for underlying assumptions and techniques. /2/ Data based on equation, Surface Area in square centimeters = 9.85 (body weight in grams)$^{0.64}$. /3/ Weights have been affected by 24-48 hrs of fasting and are accordingly lower than the normal weights of the animals. /4/ By extrapolation of smoothed curve.

155. RESTING ENERGY METABOLISM: HORSES

"Resting metabolism"[1] refers to heat production when the animal is at rest in a recumbent position, although neither in a strictly thermo-neutral environment nor in a post-absorptive condition. It is measured before the morning feeding under customary farm conditions. The resting metabolism, as thus defined, is considerably greater than the basal metabolism, the exact value depending on the nature of the diet, the time after feeding, and the environmental temperature.

Percheron Horses

	Approximate Age		Body Weight	Body Surface Area[2]	Resting Metabolism[3,4]		Oxygen Consumption[5]	Resting Metabolism[3,4]		Oxygen Consumption[5]
			kg	sq m	Cal/kg/day	Cal/sq m/day	liters/kg/day	Cal/kg/day	Cal/sq m/day	liters/kg/day
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
	Males[6]	Females	Males[6] & Females		Males[6]			Females		
1	0.1 mo	0.1 mo	75	1.52	51.5	2540	10.7	51.3	2540	10.6
2	0.6 mo	0.7 mo	100	1.82	44.8	2460	9.3	45.0	2470	9.3
3	1.6 mo	1.8 mo	150	2.35	36.9	2360	7.6	37.3	2380	7.7
4	2.8 mo	2.9 mo	200	2.82	32.2	2280	6.7	32.7	2320	6.8
5	4.0 mo	4.0 mo	250	3.23	28.9	2230	6.0	29.5	2280	6.1
6	6.0 mo	6.0 mo	300	3.63	26.5	2180	5.5	27.1	2240	5.6
7	9.5 mo	8.5 mo	350	4.00	24.6	2150	5.0	25.3	2210	5.2
8	1.2 yr	1.2 yr	400	4.35	23.0	2120	4.8	23.8	2180	4.9
9	1.5 yr	1.5 yr	450	4.70	21.8	2090	4.5	22.5	2150	4.7
10	2.0 yr	1.9 yr	500	5.02	24.1	2400	5.0	24.9	2480	5.2
11	2.3 yr	2.2 yr	550	5.33	24.5	2530	5.1	24.8	2560	5.1
12	2.9 yr	2.4 yr	600	5.63	24.9	2650	5.2	24.8	2640	5.1
13	4.2 yr	2.8 yr	650	5.92	25.2	2770	5.2	24.7	2710	5.1
14	4.8 yr	3.3 yr	700	6.21	25.6	2880	5.3	24.6	2780	5.1
15		4.1 yr	750	6.47	25.9	3000	5.4	24.6	2850	5.1
16		5.0 yr	800	6.75	26.2	3100	5.4	24.5	2910	5.1

/1/ For techniques employed and underlying assumptions see Mo. Agr. Exp. Sta. Res. Bull. 368. /2/ Based on equation, Surface Area in sq. meters = 0.1 (weight in kg)$^{0.63}$. See Mo. Agr. Exp. Sta. Res. Bull. 115, p.30. /3/ In kilocalories. /4/ For weights up to 500 kg, data based on equation, $Y = 409\ X^{0.52}$, for males and $Y = 374\ X^{0.54}$ for females. For weights over 500 kg, $Y = 7.86\ X^{1.18}$, for males and $Y = 30\ X^{0.97}$ for females. Y = resting metabolism in Calories per day and X = body weight in kg. /5/ Standard temperature and pressure. /6/ Geldings.

156. RESTING ENERGY METABOLISM: MULES

"Resting metabolism"[1] measures the energy maintenance cost, in the standing position, after intermittent light feeding (grazing). No difference has been found between standing and recumbent metabolism records in horses over the entire period of growth.

	Approximate Age	Body Weight	Body Surface Area[2]	Metabolism[3]		Oxygen Consumption[4]
		kg	sq m	Cal/kg/day	Cal/sq m/day	liters/kg/day
	(A)	(B)	(C)	(D)	(E)	(F)
	Males and Females					
1	One week	60	1.35	60.5	2685	12.5
2	Three weeks	80	1.62	54.5	2686	11.3
3	Four weeks	100	1.87	50.3	2689	10.4
4	Six weeks	150	2.42	43.5	2693	9.0
5	Four months	200	2.91	39.2	2697	8.1
6	Six months	250	3.35	36.2	2698	7.5
7	Eight months	300	3.76	33.9	2701	7.0
8	Eleven months	350	4.15	32.1	2704	6.6
9	Thirteen months	400	4.52	30.6	2705	6.3
10	Eighteen months	450	4.87	29.3	2705	6.1
11	Twenty-six mo	500	5.21	28.2	2706	5.8
12	Thirty-six mo	550	5.53	27.2	2708	5.6
13	Thirty-eight mo	600	5.85	26.4	2709	5.5
14	Fifty months	650	6.15	25.6	2710	5.3
15	Five years	700	6.45	25.0	2710	5.2

/1/ For techniques employed and underlying assumption see Kibler, H. H., and Brody, S., Mo. Agr. Exp. Sta. Res. Bull. 438, 1949. /2/ Based on equation, Surface Area in sq. meters = 0.1 (weight in kg)$^{0.636}$. See Mo. Agr. Exp. Sta. Res. Bull. 115, p. 30. /3/ Kilocalories; data based on equation, $Y = 264 X^{0.64}$, where Y = resting metabolism in Cal/day and X = body weight in kg. /4/ Standard temperature and pressure.

157. BASAL AND RESTING ENERGY METABOLISM: RATS

Values are read from smoothed curves based on tabular data and curves from the source publication[1].

Albino

	Approximate Age		Body Weight	Surface Area[2]	Resting Metabolism[3,4]				Approximate Age		Body Weight[5]	Surface Area[2]	Basal Metabolism[4,6]			
			kg	sq m	Cal/kg/day		Cal/sq m/day				kg	sq m	Cal/kg/day		Cal/sq m/day	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)
	Males	Females	Males and Females		Males	Females	Males	Females	Males	Females	Males and Females		Males	Females	Males	Females
1	<1 da[7]		0.005	0.0030	340[7]		567[7]									
2	5 da		0.010	0.0047	290		617									
3	10 da		0.015	0.0060	200		500									
4	14 da		0.020	0.0073	205		562									
5	19 da		0.025	0.0084	216		643									
6	21 da		0.030	0.0094	233		744									
7	25 da		0.035	0.0103	257		873									
8	29 da		0.050	0.0129	280		1085		31 da		0.050	0.0129	240		930	
9	35 da	36 da	0.075	0.0167	267		1199		37 da	38 da	0.075	0.0167	227		1019	
10	40 da	42 da	0.100	0.0200	260	240	1300	1200	42 da	45 da	0.100	0.0200	210		1050	
11	49 da	54 da	0.150	0.0258	193	167	1122	971	52 da	62 da	0.150	0.0258	160	153	930	890
12	60 da	120 da	0.200	0.0310	155	135	1000	871	64 da	140 da	0.200	0.0310	140	118[7]	903	761[7]
13	82 da		0.250	0.0356	132		927		87 da		0.250	0.0356	124		871	
14	100 da		0.300	0.0400	113		848		120 da		0.300	0.0400	107		802	

/1/ See source publication for underlying assumptions and techniques. /2/ Data based on equation, Surface Area in sq. meters = 0.0011 (body weight in grams)$^{0.63}$. /3/ Authore' "day-to-day" metabolism. Method permitted observation of animals' activity, thus eliminating from the results any values affected by activity. /4/ Kilocalories. /5/ Weights have been affected by 14-20 hrs of fasting and are accordingly lower than the normal weights of the animals. /6/ Basal metabolism calculated from 14-20 hour fasting oxygen consumption of the resting animal. /7/ By extrapolation of smoothed curve.

158. RESTING AND FASTING ENERGY METABOLISM: SWINE

"Resting metabolism"[1] refers to heat production when the animal is at rest in a recumbent position, though not in a strictly thermo-neutral environment nor in a post-absorptive condition, but as measured before the morning feeding under customary farm conditions. The resting metabolism as defined is considerably above the basal metabolism, the exact value depending on the nature of the diet, on time after feeding and on environmental temperature. Fasting metabolism[1] = 24-hr fasting; does not necessarily represent basal metabolism.

	Approximate Age	Body Weight	Body Surface Area[2]	Duroc Jersey Swine			Chester White Swine			Duroc Jersey and Chester White Swine		
				Resting Metabolism[3,4]		Oxygen Consumption[5]	Resting Metabolism[3,6]		Oxygen Consumption[5]	24-hr Fasting Metabolism[3,7]		Oxygen Consumption[5]
		kg	eq m	Cal/kg/day	Cal/sq m/day	litere/kg/day	Cal/kg/day	Cal/sq m/day	litere/kg/day	Cal/kg/day	Cal/sq m/day	litere/kg/day
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
	Males											
1	1.5 mo	5	0.27	77.2	1440	16.0	77.2	1440	16.0			
2	3.3 mo	10	0.42	67.6	1620	14.0	67.6	1620	14.0			
3	4.3 mo	15	0.54	64.3	1790	13.3	64.3	1790	13.3	41.8	1160	8.7
4	5.0 mo	20	0.65	62.7	1940	13.0	62.7	1940	13.0	41.0	1270	8.5
5	5.3 mo	25	0.75	61.8	2070	12.8	61.8	2070	12.8	38.6	1300	8.0
6	7.3 mo	50	1.15	57.9	2510	12.0	57.9	2510	12.0	33.8	1460	7.0
7	9.4 mo	75	1.49	37.3	1880	7.7	41.2	2070	8.5	30.9	1550	6.4
8	11.0 mo	100	1.79	33.8	1890	7.0	38.6	2160	8.0	26.5	1480	5.5
9	1.3 yr	150	2.31	28.9	1880	6.0	35.1	2270	7.3	21.9	1420	4.5
10	1.8 yr	200	2.78	25.8	1860	5.3	32.8	2360	6.8	19.3	1390	4.0
11	2.1 yr	250	3.19	23.7	1860	4.9	31.1	2430	6.4	17.4	1360	3.6
	Females											
12	1.5 mo	5	0.27	77.2	1440	16.0	77.2	1440	16.0			
13	3.0 mo	10	0.42	72.4	1740	15.0	72.4	1740	15.0	43.4	1040	9.0
14	4.0 mo	15	0.54	67.5	1880	14.0	67.5	1880	14.0	38.6	1080	8.0
15	4.7 mo	20	0.65	67.6	2090	14.0	67.6	2090	14.0	38.6	1190	8.0
16	5.1 mo	25	0.74	65.6	2210	13.6	65.6	2200	13.6	36.7	1230	7.6
17	6.6 mo	50	1.16	60.8	2630	12.6	60.8	2630	12.6	31.8	1380	6.6
18	8.3 mo	75	1.49	40.5	2040	8.4	40.5	2040	8.4	30.2	1520	6.3
19	10.0 mo	100	1.79	33.3	1860	6.9	36.2	2020	7.5	23.2	1290	4.8
20	1.1 yr	150	2.31	25.1	1627	5.2	30.6	1980	6.3	18.7	1210	3.9
21	1.5 yr	200	2.77	20.8	1500	4.3	27.3	1960	5.6	15.9	1150	3.3
22	2.1 yr	250	3.19	17.8	1390	3.7	25.1	1960	5.2	14.1	1100	2.9

/1/ For techniques employed and underlying assumptions see Brody, S., and Kibler, H. H., Mo. Agr. Exp. Sta. Res. Bull. 380, 1944. /2/ Based on equation, Surface Area in sq. meters = 0.097 (weight in kg)$^{0.633}$. See Mo. Agr. Exp. Sta. Res. Bull. 115, p.30. /3/ In kilocalories. /4/ Up to 50 kg, for males, data based on equation, Y = 88.1 X$^{0.89}$, and for females, Y = 89.9 X$^{0.90}$; over 50 kg, for males, Y = 194 X$^{0.62}$, and for females, Y = 764 X$^{0.32}$, where Y = resting metabolism in Calories/day and X = body weight in kg. /5/ Standard temperature and pressure. /6/ Up to 50 kg, for males, data based on equation, Y = 88.1 X$^{0.89}$, and for females, Y = 89.9 X$^{0.90}$; over 50 kg, for males, Y = 117 X$^{0.76}$, and for females, Y = 228 X$^{0.60}$, where Y = resting metabolism in Calories/day and X = body weight in kg. /7/ Up to 50 kg, for males, data based on equation, Y = 73.4 X$^{0.80}$ and for females, Y = 62.8 X$^{0.83}$; over 50 kg, for males, Y = 221 X$^{0.54}$ and for females, Y = 295 X$^{0.45}$, where Y = 24-hr fasting metabolism in Calories/day and X = body weight in kg.

159. RESTING AND FASTING ENERGY METABOLISM: CHICKENS

Values are read from smoothed curves based on tabular data and curves in the original source publication[1].

Rhode Island Red

	Approximate Age		Body Weight	Surface Area[2]	Resting Metabolism[3,4]				Approximate Age		Body Weight[5]	Surface Area[2]	Fasting Metabolism[4,6]			
			kg	sq m	Cal/kg/day		Cal/sq m/day				kg	sq m	Cal/kg/day		Cal/sq m/day	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)
	Males	Females	Males & Females		Males	Females	Males	Females	Males	Females	Males & Females		Males	Females	Males	Females
1	Hatching	Hatching	0.040	0.011	200		727									
2	5 da	7 da	0.050	0.013	210		808									
3	15 da	20 da	0.100	0.021	220		1048									
4	20 da	25 da	0.150	0.028	215		1152									
5	25 da	31 da	0.200	0.034	205		1206									
6	29 da	35 da	0.250	0.040	202	180	1263	1125								
7	52 da	59 da	0.500	0.065	120	114	923	877	55[7] da	64[7] da	0.500	0.065	84[7]	100[7]	646[7]	769[7]
8	82 da	94 da	1.000	0.107	100	95	935	888	86 da	100 da	1.000	0.107	80	78	748	729
9	101 da	125 da	1.500	0.142	90	83	951	877	105 da	150 da	1.500	0.142	77	67	813	708
10	129 da	200 da	2.000	0.174	90	77	1034	885	131 da	250 da	2.000	0.174	75	60	862	690
11	160 da	>365 da	2.500	0.204	88	72	1078	882	166 da	>365 da	2.500	0.204	72	56	882	686

/1/ See source publication for underlying assumptions and technique. /2/ Data based on equation, Surface Area in square centimeters = 8.19 (body weight in grams)$^{0.705}$. /3/ Method permitted observation of animals' activity, thus allowing elimination from the results such values that may have been affected by any activity. /4/ Kilocalories. /5/ Weights have been affected by 24 hrs of fasting and are accordingly lower than the normal weights of the animals. /6/ Fasting metabolism calculated from 24 hour fasting oxygen consumption of the resting animal. /7/ By extrapolation on smoothed curve.

160. METABOLIC RATES: SOIL ORGANISMS

(See next page for columns G-K of this table)

In columns B D F I the following symbols are used; μμ = a millionth of a millionth (10^{-12}); μ = a millionth (10^{-6}); m = a thousandth (10^{-3}); M = million (10^{6}). Values in columns I J K are included to indicate order of magnitude of the metabolic activity of populations.

	Groups and Species	Weight	Temperature[1]	Metabolic Rate		
				Calories[2]		O_2 Consumption
		mg	°C	Cal/hr/ind[3]	Cal/hr/ind[3]	ml/hr/ind[3]
	(A)	(B)	(C)	(D)	(E)	(F)
1	Bacteria					
2	Sarcina lutea	1,000 μμ	20.5	33 m μμ	33	7 μμ
3	Fungi					
4	Mycoderma sp.	100,000 μμ	20.0	0.024 m μ	238	4,930 μμ
5	Saccharomyces sp.	180,000 μμ	20.0	8.7 μμ	48.1	1,790 μμ
6	Protozoa					
7	Chaos chaos (amoeba)	0.05	22.5	42-62 m μ	0.83-1.24	8.6-12.9 μ
8	Nematoda					
9	Monhystera	0.2-0.3	16.0	1.45-2.17 μ	6.14-8.34	300-450 μ
10	Plectus	0.5-1.0	16.0	2.9-5.8 μ	4.8-6.8	600-1,200 μ
11	Dorylaimus	0.3-56	16.0	1.93-216 μ	2.4-5.3	400-44,800 μ
12	Annelida					
13	Lumbricus terrestris (earthworm)	500	17-20	0.145 m	0.29	0.03
14	Lumbricus terrestris (earthworm)	5,000	20-23	1.45 m	0.29	0.3
15	Lumbricus terrestris (earthworm)	1,210	13.0	0.424 m	0.35	0.09
16	Mollusca					
17	Helix aspersa (garden snail)	10,000	10.0	2.06 m	0.206	0.426
18	Helix aspersa (garden snail)	10,000	20.0	4.24 m	0.424	0.876
19	Acari					
20	Oribatei					
21	Euzetes aterrimus	0.25	14.5	150-193 m μ	0.6-0.77	31-40 μ
22	Notaspis coleoptratus	0.03	11.3	48.3 m μ	1.59	10 μ
23	Parasitiformes					
24	Macrocheles sp.	0.25	12.0	483 m μ	1.93	100 μ
25	Araneae					
26	Lycosa sp.	15.1	13.0	33.2 μ	2.2	6,870 μ
27	Opilliones					
28	Nemastoma sp.	3.8	13.0	9.17 μ	2.415	1,900 μ
29	Coleoptera					
30	Carabus nemoralis (ground beetle)	644	13.0	767 μ	1.19	0.159
31	Staphilinus olens (rove beetle)	247	13.0	285 μ	1.15	0.059
32	Epaphius secalis (ground beetle)	1.2-2.2	13.0	7-9.8 μ	5.92	1,500-2,000 μ
33	Notiophilus biguttatus (ground beetle)	7.5	13.0	36 μ	4.8	7,600 μ
34	Diptera					
35	Tipula sp. (larva)	277	13.0	285 μ	1.03	0.059
36	Tipula sp. (larva)	607	13.0	502 μ	0.825	0.104
37	Collembola					
38	Pogonognathus plumbens	1.3-2.5	13.0	6.5-9.3 μ	5.02-3.7	1,400-1,900 μ
39	Orchesella flavescens	1.8-3.5	13.0	5.3-11.7 μ	2.93-3.34	1,100-2,400 μ

/1/ Temperature used in determining values in columns D-G. Values in column K are reduced to the common standard of 16° C according to Krogh's curve. /2/ Kilocalories. /3/ Individual.

160. METABOLIC RATES: SOIL ORGANISMS (Concluded)

(See preceding page for columns B-F of this table)

In columns B D F I the following symbols are used: μμ = a millionth of a millionth (10^{-12}); μ = a millionth (10^{-6}); m = a thousandth (10^{-3}); M = million (10^{6}). Values in columns I J K are included to indicate order of magnitude of the metabolic activity of populations.

	Groups and Species	Metabolic Rate (Concluded)	Respiratory Quotient[3]	Typical Estimates, Natural Soils[4]		
		O_2 Consumption		Number	Mass	Metabolism
		L/kg/hr		Per sq m	g/sq m	Cal/hr/sq m^2
	(A)	(G)	(H)	(I)	(J)	(K)
1	Bacteria			200-1,200 MM	200-1,200	330 m
2	Sarcina lutea	7	0.71			
3	Fungi				40-400	
4	Mycoderma sp.	49	(0.82)			
5	Saccharomyces sp.	10	(0.82)			
6	Protozoa			100-500 M	38	21-32 m
7	Chaos chaos (amoeba)	0.17-0.25	(0.82)			
8	Nematoda			0.175-20 M	0.7-17.8	4.2-107 m
9	Monhystera	1.3-1.7	0.83			
10	Plectus	1-1.4	0.83			
11	Dorylaimus	0.5-1.1	0.83			
12	Annelida			50-2,000	1.6	0.48 m
13	Lumbricus terrestris (earthworm)	0.06	(0.82)			
14	Lumbricus terrestris (earthworm)	0.06	(0.82)			
15	Lumbricus terrestris (earthworm)	0.073	(0.82)			
16	Mollusca			0-8,500	0-50	0-15 m
17	Helix aspersa (garden snail)	0.043	(0.82)			
18	Helix aspersa (garden snail)	0.088	(0.82)			
19	Acari				4.5	6.75 m
20	Oribatei			2,100-121,000	0.07-0.83	0.105-1.24 m
21	Euzetes aterrimus	0.124-0.16	(0.82)			
22	Notaspis coleoptratus	0.33	(0.82)			
23	Parasitiformes			200-7,400	0.09-0.22	0.13-0.33 m
24	Macrocheles sp.	0.4	(0.82)			
25	Araneae			175-637	0.637	0.39-1.4 m
26	Lycosa sp.	0.455	(0.82)			
27	Opilliones			1.6-38	0.005-0.148	0.016-0.47 m
28	Nemastoma sp.	0.5				
29	Coleoptera				3.8	6.1 m
30	Carabus nemoralis (ground beetle)	0.247	(0.82)			
31	Staphilinus olens (rove beetle)	0.239	(0.82)			
32	Epaphius secalis (ground beetle)	1.225	(0.82)			
33	Notiophilus biguttatus (ground beetle)	0.878	(0.82)			
34	Diptera				1.0	1.35 m
35	Tipula sp. (larva)	0.214	(0.81)			
36	Tipula sp. (larva)	0.171	(0.82)			
37	Collembola			40-40,000	6.85	27-46 m
38	Pogonognathus plumbens	0.768-1.04				
39	Orchesella flavescens	0.606-0.691				

/2/ Kilocalories. /3/ O_2 consumed ÷ CO_2 liberated. Values in parenthesis are assumed. The value 0.82, is usually assumed because this is the mean value for protein, and whatever the ratio of fat to carbohydrate in the food the values calculated will differ by no more than 3.5% from the true values. /4/ Values are reasonably accurate estimates from the literature and represent mean annual abundance. Bacteria values unreliable.

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The system for presenting bibliographic references used here has been adapted from one in common use in geographic atlases. An item in a table is identified by two coordinates, a letter designating the column, and a number the row, in which the item appears. In a typical instance in the bibliography, the coordinates of an item are followed in the column to the right, by a number accompanied by a small letter. The number refers to the bibliographic source, the letter to the person contributing the item. If an item in a table is based on another item from another part of the same table, the coordinates of the latter are given as source, enclosed in parentheses.

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2. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: AMINO ACIDS, PEPTIDES, PROTEINS

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3. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: LIPIDS

Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References
1-12 B	2,119,120	11 E	1	4 I	14,26,72,97
1,2 B	1	12 E	111,112	5 I	14,26,[97-100]
3,4 B	94	1-12 F	9,10,15	6 I	101
5-11 B	1	1-12 F	1	7 I	14,26,57,66
12 B	95	1-12 G	[11-13],15,18	8 I	98
1-12 C	[3-7]	1-12 G	1	9 I	101
1 C	28	1-12 H	6,[11-13),18	10,11 I	26,102
2-5 C	1	1 H	12,13,16,25,27, [30-34],63,64,	12 I	26,29,70,100 107
7 C	[76-78]				
9 C	37, [76-78]		74,82,113	1-12 K	20,21,55,106
10 C	92,93	2 H	13,[30-34]	1 K	20,21,[79-81),121
11-12 C	1	3 H	12,13,[30-34]	2 K	20,21
1-12 D	[3-7]	4 H	12,13,26,[30-34]	3 K	50
1 D	23,24	5 H	123,124	4 K	50,[83-91],121
2,3 D	1	7 H	35,75,115	5 K	51
4 D	24,110	9 H	13,17,113	6 K	103
5-12 D	1	10 H	17,26,116,117	7 K	20,21,52,55,[58- 62),65,67,68
1-12 E	[3-7]	11 H	17,26,116,117		
1 E	29,118	12 H	13,17,30	8 K	103,121
2-5 E	1	1-12 I	14,22,104,105	9 K	21,55,56,71
7 E	[41-49]	1 I	14,22,26,27,72, [96-100],114,125	10,11 K	1
9 E	6,19,[38-49], [53-55],73			12 K	21
		2 I	14,26,72,[96-100]	Fn 4-13	122
10 E	108,109	3 I	26		

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4. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: VITAMINS AND RELATED COMPOUNDS

Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References
1-49 B	540,699	23 C	2,359,540	1-49 D	2,6,[8-11],[16-18], 23,201,540,699
1-49 C	2,359,540,699	24 C	1,359,540		
1 C	2,3,347,359,540	25 C	2,[4-6],359,540	1 D	2,3,216,[219-221], 540
2 C	2,3,348,359,540	26-28 C	1,359,540		
3 C	2,[3-6],349,359,540	29 C	2,3,356,359,540	2 D	2,3,45,216,222, 444,540
4 C	2,[3-6],350,359,540	30,31 C	1,359,540		
5 C	2,4,351,359,540	32 C	2,359,540	3 D	2,[4-6],13,216, [222-224],240, 345,443,540
6 C	2,3,359,540	33-35 C	1,359,540		
7 C	2,3,6,352,359,540	36 C	2,[4-6],351,359,540		
8 C	2,[4-6],353,359,540	37 C	2,[4-6],349,359,540	4 D	[4-6],216,227,345, 540
9 C	2,[3-5],351,359,540	38 C	2,[4-6],359,540		
10,11 C	2,[4-6],354,359,540	39 C	1,359,540	5 D	1,2,216,540
12 C	2,[4-6],351,359,540	40 C	2,4,5,359,540	6 D	2,3,216,540
13 C	2,[4-6],349,359,540	41,42 C	1,359,540	7 D	3,6,13,216,540
14-16 C	2,[4-6],349,355, 359,540	43 C	2,[4-6],349,359,540	8 D	2,[4-6],14,216,223, 224,345,443,444, 540
		44 C	2,4,5,359,540		
17 C	2,[4-6],349,359,540	45 C	2,7,359,540		
18 C	2,[4-6],351,359,540	46 C	1,359,540	9 D	[1-3],216,540
19 C	2,[4-6],349,359,540	47 C	2,[4-6],359,540	10,11 D	2,[4-6],8,15,216, 223,225,345,443, 444,540,681,682
20,21 C	1,359,540	48 C	2,3,356,359,540		
22 C	2,[4-6],359,540	49 C	2,4,5,359,540		

(Continued on the next page)

Data Coordinates and Footnotes	Contributors and References
12 D	2,[4-6],216,226, 345,444,540
13 D	1,[4-6],216,540, 604,673
14-16 D	2,[4-6]216,222, 224,345,443,540, 598,673,693,694
17 D	2,8,9,216,345,444, 540,658
18 D	2,9,18,19,[24-29], 41,202,216,[223-225],335,345,443, 444,540
19 D	[4-6],8,13,35,202, 222,540
20 D	598,599
21 D	1,540
22 D	1,11,540
23 D	1,540
24 D	1,8,9,[608-611]
25 D	8,539,540
26 D	[4-6],13,49,540
27 D	1,604
28 D	1
29 D	1,3,20,21,539,540
30 D	1,9
31,32 D	1,540
33 D	1,480,540
34 D	1,9
35 D	1
36 D	1,[4-6],13,540
37 D	2,10,12,18,23,216, 222,443,444,540
38 D	[4-6],9,13,22,23, 540
39 D	1,540
40 D	1,4,5,539,540
41,42 D	[4-6],8,9,13,49
43 D	[4-6],9,24,[30-32], 216,335,539,540
44 D	1,4,5,539,540
45 D	1,7,540
46 D	1,540
47 D	[4-6],30,31,33,34, 216,335,444,539, 540
48 D	1,3,20,21,539,540
49 D	1,4,5,540
1-49 E	6,8,[9-12],16, 227,540,699
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2 E	3,9,45,540
3 E	[4-6],9,13,[42-44], [47-49],162,180, 218,227,441,540, 565
4 E	1,[4-6],13,49,227, 540,656
5 E	1,540
6 E	3,9,540,566
7 E	3,6,9,13,540
8 E	[4-6],10,13,38,43, [47-49],162,179, 180,216,227,239, 441,540,634
9 E	1,3,9,216,540
10,11 E	[4-6],12,13,43,49, 162,216,441,540, 567,568,[679-682]
12 E	[4-6],9,13,43,49, 162,216,227,240, 242,441,540
13 E	1,[4-6],13,49,216, 540,604,673
14-16 E	[4-6],13,43,[46-49],216,227,441, 540,567,598,601, 604,623,673,694
17 E	[4-6],9,13,49,216, 540,673
18 E	[36-40],43,144,216, [227-233],441, 540,[568-571],602
19 E	[4-6],11,13,49,241, 540,673,686
20 E	598,599,603
21,28,30-32,39 E	1,540
22 E	9,11,52,368,540
23 E	1,53,540
24 E	1,8,9,540,608,611
25 E	369,540
26 E	[4-6],13,49,540, 673,688
27 E	604
29 E	1,3,20,21,540
33 E	1,480,540
34 E	1,[673-678]
35 E	1
36 E	[4-6],13,49,540
37 E	[4-6],13,49,191, 192,442,540
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41,42 E	[4-6],13,49,540
43 E	[4-6],13,36,37,39, 40,43,49,231,540
45 E	1,7,540
46 E	1,3,20,21,540
47 E	[4-6],11,13,36,37, 39,40,43,49,231, 540
48 E	369,540
49 E	1,540
1-49 F	4,5,10,11,12,16, 49,144,699
1 F	1,3,10,540,596,597
2 F	3,10,11,61,62,362, 363,540,560
3 F	4,5,8,[10-13],49, [163-169],144, 227,360,540
4 F	4,[10-12],63,64, 144,450,540
5 F	4,11,65,66,144,169, 170,540,561,562
6 F	1,3,10,540
7 F	1,3,6,10,13,540
8 F	4,[10-12],49,540,563
9 F	3,11,144,365,540
10 F	4,5,[10-13],49,144, [181-183],360,540, 681,682,684,685
11 F	4,5,[10-13],49,144, [181-183],360, 540,[681-684]
12 F	[4-6],[10-13],49,[67-77],144,183,184, 360,493,525,540
13 F	[4-6],11,12,144, [171-178],480,493, 540,564,604,673
14,15 F	[4-6],[10-13],49, [78-81],144,168, 183,185,540,601, 623,624,673,[691-693]
16 F	[4-6],[10-13],49, [78-81],144,168, 183,185,540,601, 623,624,673
17 F	4,5,[10-13],49,[82-88],144,184,[186-188],540,673
18 F	[4-6],[10-13],[89-93],144,184,189, 540,657
19 F	[4-6],[10-13],190, 366,540
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21 F	1,540
22 F	[4-6],11,[50-52], 368,493,540
23 F	1,53,540
24 F	8,9,538,604,605,608
25 F	[4-6],[11-13],49, 94,95,144,370, 540
26 F	4,5,6,13,144,540, 541,657,673,689, 690
27 F	[4-6],13,49,540, 604,625,673
28 F	480,493,604,[626-633],639,644, 645,493
29 F	1,3,20,21,540
30 F	604,605
31 F	493,[614-620]
32 F	[55-57],364,480, 540
33 F	1,480,529,540
34 F	538,606,607,659, 660,[673-678]
35 F	612,613
36 F	[4-6],[11-13],49, 183,364,367, 525,540,673,687
37 F	[4-6],[10-13],49, 144,540
38 F	[4-6],[10-13],49, 194,364,540
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40 F	4,5,11,540
41,42 F	[4-6],11,13,49,144, 540,598,600, 621,622
43 F	[4-6],[11-13],49, 195,540
44 F	4,5,11,364
45 F	1,7,540
46 F	1,3,20,21,540
47 F	[4-6],[11-13],49, 195,364,540
48 F	[4-6],[11-13],49, 94,95,144,470, 540
49 F	3,540
1-49 G	[96-98],113,540, 699
1 G	1,96, 97,98
2 G	99
3,4 G	96,97,98
5 G	117
6-14 G	96-98
15 G	100
16-42 G	1,[96-98],358
43 G	100
44-46 G	1,[96-98]
47 G	100
48,49 G	1,[96-98]
1-49 H	16,97,98,[101-103],113,118, 540,699
1,2 H	1,540
3 H	115,117,540
4 H	1,540
5 H	98,[115-117],127, 540,648
6-17 H	1,540
18 H	98,[101-103],115, 117,127,540
19-22 H	1,540
23 H	116,540
24-38 H	1,540

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39 H	542
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43 H	4,98,[101-103],111,115,117,127,540
44 H	1,540
45 H	116,540
46 H	1,540
47 H	4,98,[101-103],111,115,117,127,540
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49 H	1,116,540
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2 I	102,103,114,123,125,126,540,[573-575]
3 I	102,103,107,[270-273]540,[576-578]
4 I	1,103,271,579
5 I	[102-104],108,117,273,439,540
6 I	1,[101-103],540
7 I	1,[101-103],540,662,665
8 I	1,103,540,655
9 I	1,108,540
10,11 I	4,[102-104,107,112,119,120,122,272,540,581
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13 I	[102-104],107,109,271,287,540,580,673
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17 I	4,[101-104],[107-109],120,122,[270-273],540,582,583,585,589
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23 I	1,103,116,540
24 I	1,540
25 I	103,577,590
26 I	1,540
27 I	1,540,543,636,637,695,696
28 I	697
29-35 I	1,540
36 I	1,4,6,540,589
37 I	102,103,270,272,308,540,591,592
38 I	103,540
39 I	1,540
40 I	107,540,593
41,42 I	[4-6],13,49,103,540,543
43 I	4,[101-103],111,124,540,594,595
44 I	1,4,5,103,104,540
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47 I	4,[101-103],111,124,540,594,595
48 I	103,577,590
49 I	1,540
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4 J	4,5,128,129,134,138,146,[149-151],[153-155],280,447,448,540
5 J	1,128,147,448,540
6 J	128,129,148,253,448,540,563
7 J	128,129,247,448,540,564
8 J	4,5,128,129,138,139,[149-151],156,448,540
9 J	128,129,146,156,448,540
10,11 J	4,5,128,129,135,140,141,[149-151],[154-157],160,448,540,565
12 J	4,5,128,129,135,142,143,[149-151],[154-157],448,540,566
13 J	4,5,128,[135-137],149,153,156,161,269,286,448,460,540,566,568
14-16 J	4,5,128,129,135,143,[149-151],[153-159],448,540
17 J	4,5,128,129,135,145,[149-151],[153-159],448,540,565
18 J	4,5,128,129,135,[149-151],[153-159],448,540,567
19 J	1,[4-6],448,540
20,21 J	1,540,598,599
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25 J	1,128,448,540
26 J	4,5,540
27 J	540,604,635
28 J	1,540
29 J	1,128,448,540
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32 J	1,55,128,448,540
33-35 J	1,540
36 J	1,[4-6],540
37 J	1,128,129,133,[149-151],448,540
38 J	1,128,540
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40 J	1,128,540
41,42 J	[4-6],540
43,44 J	1,28,540
45 J	1,106,128,540
46 J	1,540
47 J	1,128,540
48 J	1
49 J	128,540
21 K	545
1-49 L	[3-5],[58-60],215,[371-377],454,480,540,545,[556-561],699
1 L	3,58,204,215,217,[243-246],[378-393],[452-459],540,545,546,654,662
2 L	3,58,204,212,215,217,244,261,262,336,341,[371-377],480,[496-524],540,545,547
3 L	[3-5],58,212,215,217,[263-268],336,394,540,545,548,651,653
4 L	4,5,58,204,215,217,266,[274-279],336,342,[394-399],449,451,480,540,545,549
5 L	4,204,214,215,217,332,333,343,344,[400-403],[480-492],540,545
6 L	3,58,212,215,217,244,[248-252],[404-416],[460-474],540,545,550,654,[666-672]
7 L	3,58,204,211,212,215,217,240,[254-257],[336-339],417,418,[475-479],540,545,551,654
8 L	[3-5],58,204,215,217,252,[288-292],394,480,540,545,552
9 L	3,58,204,215,217,[258-260],340,419,540,545,553
10,11 L	4,5,58,203,213,215,217,252,[292-297]420,480,540,545,658
12 L	[3-5],58,206,215,217,227,263,267,[298-302],[421-425],480,[525-528],540,545
13 L	4,5,58,204,212,215,217,252,[281-285],[371-377],480,[493-495],[505-508],540,545,640,649,661
14-16 L	[3-5],58,203,215,217,263,279,[309-314],[426-429],480,540,545,554,555,673
17 L	[3-5],58,204,215,217,258,263,279,[316-324],419,[430-434],480,540,545
18 L	[3-5],58,208,215 217,278,[325-331],[435-438],480,540,545
19 L	[3-5],206,540
20 L	1,540,598,599,652
21 L	3,540,545,654,[662-664]
22 L	[3-6],206,209,480,493,540,650
23 L	106,540
24,30,31 L	1,540

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Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References
25 L	[4-6],540	35 L	1,540,604	43 L	[4-6],208,540
26 L	4,5,540	36 L	[3-6],206,540	44 L	4,5,540
27 L	4,5,540,604,661	37 L	[3-6],204,[303-307],540,545	45 L	106,540
28 L	1,540,639,640, 646,647	38 L	[4-6],540	46 L	3,20,21,203,540
29 L	3,20,21,203,540	39 L	1,480,540,641, 642,643	47 L	[3-6],208,540
32 L	11,480,540			48 L	[4-6],540
33 L	1,480,[529-537],540	40 L	[3-5],204,540	49 L	4,5,540,545
34 L	1,540,604,659,660	41,42 L	[4-6],540	Fn 5-26	698

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5. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: PURINES, PYRIMIDINES

Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References
1,2 B	1,2,129	20 D	136	1 H	[12-16],18,23,51, 66
3-7 B	1,2	21 D	1	2 H	[12-16],18,51,111, 114
8,9 B	1,2,130	1-22 E	[3-8],23,60,96,145	3 H	[13-16],18,51,64, 65,89
10 B	1,2,131	1 E	[5-7],[20-23],37, 66	4 H	13,14,52,53,56, 62,89,111
11,12 B	1,2	2 E	[5-7],20,23,[34-36]	5 H	[13-15],51,89, 111
13 B	1,2,132	3 E	5,88,100	6 H	[13-15]
14,15 B	1,2	4 E	5,88,91	7 H	13,14,111,124
16 B	1,2,133	5 E	5,20,88,100	8 H	[13-15],54,111
17 B	1,2,134	6 E	5,7,37,39,100, 101,116	9 H	13,14
18,19 B	1,2	7 E	[5-7],[20-23],37, 66	10 H	[13-15],[51-53], 89,111
20 B	1,2,135	8 E	6,20,38,67,86,88	11,12 H	13,14,51,89
21 B	1,2,134	9 E	[40-42],92,101, 102,143	13 H	[13-15],50,51,59, 63,64,106
22 B	1,2	10 E	5,7,20,[24-32], 97,98,143	14 H	[13-15],81,89,106
1-22 C	[3-8],23,60,76, 115,145	11 E	5,88,100	15 H	13,14,106
1 C	3,4,58,66,72,78, 79,99,113,127, 138	12 E	5,91	16 H	13,14,51,52,89, 106,111
2 C	3,4,23,76,113,138	13 E	20,43,45,[83-85], 143,144,146, 147	17 H	[13-15],61,63,64, 89,106,111
3 C	3,4,99,138	14 E	[83-88],144,146,147	18 H	13,14,51,89,106
4 C	3,5,99,113,138	15 E	5,7,90,144	19 H	5,13,14,[51-53], 56,62,106,111
5 C	138	16 E	5,7,91,144,146,147	20 H	[13-15],89,106
6 C	3,4,99,113,138	17 E	5,20,[83-88],92, 143	21 H	[13-15]
7 C	3,4,58,66,72,78, 79,113,127,138, 148	18 E	5,[83-85],92,146, 147	22 H	150
8,9 C	1	19 E	5,7,88,91	1-22 I	17,60
10 C	3,99,113,138	20 E	[5-7],[86-88],92, 96,100,143	1 I	1,17
11 C	99,138	21 E	5,7,[83-88],92,96	2 I	17,110
12 C	3,5,99,113,138	1-22 F	[9-11],60,61,[121-123]	3-6 I	1,17
13 C	3,4,86,113,137,138	1 F	48,57	7 I	1,17,110
14 C	3	2-6 F	1	8 I	17,94
15 C	3,4	7 F	128	9 I	1,17
16 C	1	8,9 F	1	10 I	17
17 C	3,4,[72-74],[80-82],137,138	10 F	48,57	11-12 I	1,17
18 C	3	11-21 F	1	13 I	17,93
19 C	1	1-22 G	[11-14],16,55,60, 107	14-15 I	1,17
20 C	24,25,[73-75],138	1 G	[11-14],23,46,47, [47-49]	16 I	17,110
21 C	1	2-6 G	13,14,16,49	17 I	17,93
1-22 D	[3-8],23,60,77,145	7 G	[11-14],49,124	18-21 I	1,17
1 D	19,125,126,136	8 G	14,49	1-21 K	[139-142],145
2 D	33,125,126,136	9 G	14,49,54,108	1 K	1,112
3,4,6 D	1	10-12 G	13,14,16,49	2 K	109,112
5 D	125,136	13 G	13,14,49,55	3-5 K	1
7 D	19	14-16 G	13,14,16,49	6 K	1,102
8,9 D	1	17 G	13,14,49,55	7 K	1,109
10 D	136	18-21 G	13,14,16,49	8 K	[68-71]
11,12 D	1			9 K	1,104
13 D	33,125,136,144, 146,147			10-15 K	1
14 D	144,146,147			16 K	105
15 D	144			17-21 K	1
16 D	144,146,147			Fn 4-26	151
17 D	5,33,125				
18 D	146,147				
19 D	1				

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(Continued on the next page)

5. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS: PURINES, PYRIMIDINES (Concluded)

Reviewers: Berg, C. P.; Bird, H. R.; Blinks, L. R.; Briggs, G. M.; Cantino, E. C.; Csonka, F. A.; Danforth, W.; Dewey, V. C.; El-Ani, A.; Elliott, A. M.; Evans, R. J.; Fogg, G. E.; Foster, J. W.; Gordon, H. T.; Halver, J. E.; Hanson, R. W.; Haskins, R. H.; Hibbs, J. W.; Holz, G. G., Jr.; House, H. L.; Koser, S. A.; Ledingham, G. A.; Lindegren, C. C.; Loefer, J. B.; MacVicar, R. W.; Mills, R. C.; Minarik, C. E.; Moore, W. B.; Neish, A. C.; Nightingale, G. T.; Noland, J. L.; Norris, L. C.; Paretsky, D.; Perlman, D.; Pomerene, E.; Pomper, S.; Porges, N.; Robbins, W. J.; Robbins, W. R.; Rusoff, L. L.; Scott, M. L.; Shorb, M. S.; Shu, P.; Simpson, F. J.; Steinberg, R. A.; Tatum, E. L.; Turrell, F. M.; van Wagtendonk, W. J.; Vishniac, H. S.; Wolf, F. T.

6. NUTRIENTS: ESSENTIAL ORGANIC COMPOUNDS, MISCELLANEOUS GROWTH FACTORS

Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References
1 B	1,82,142	1 E	1	6 H	[29-31],33,58,59, 61,195
2 B	1,82,142,183	2 E	[9-11],182		
3 B	12,184	3 E	13,14,146	10 H	1,[29-34]
4 B	1,17,185	4 E	9,10,20,[23-25], 147	11 H	1,31,32
5 B	1,82,142			12 H	31
6 B	142,195	5 E	38,[168-171]	13 H	33,[35-37]
7-9 B	1,82,142	6 E	9,10,43,[50-57], 148,149,195	14 H	30,31,[87-90]
10 B	1,17,185			15 H	[29-31],33,37, 87,96,136
11 B	1,82,142,186	7 E	208,209		
12 B	1,82,142,194	8 E	1	16-22 H	1
13 B	[80-82], 187	9 E	67	23 H	[29-31],33,34,37, 87
14 B	1,82,142,188	10 E	9,10,20,[23-25], 150	24 H	31,32,88,89,111, 112,[114-116], 119,121
15 B	1,82,142,189				
16,17 B	1	11 E	9,68,73,74,151		
18-22 B	1,82,142	12 E	8	25 H	[29-31],88,[116-118],120,[122-136]
23 B	1,82,142,184	13 E	84,85		
24 B	1,82,142	14 E	4,25,68,86,152		
25 B	190	15 E	91,92,172,173		
1 C	1	16 E	191	1,3,5,6,8,9 I	1,27
2 C	[5-10],202,203	17 E	193	2 I	207
3 C	13	18 E	1,9,99,182	4 I	27
4 C	7,8,22,165	19 E	10,101,154	7 I	27,[62-64],65, 161,162,208,209
5 C	1	20 E	110		
6 C	7,8,[40-49],69, 167,195,201,204	21 E	97,182	10 I	27
		22 E	10,101,154	11 I	27,140,141,163
7 C	1	23 E	9,[101-108],153, 160,[175-179]	12,13,15 I	1,27
8 C	66,70			14 I	27,164
9 C	1	24 E	[111-113],116,145	16,17 I	1
10 C	7,8,22,165	25 E	9,10	18,19,22,24 I	1,27
11 C	1,8,22	1-3 F	1	20,21 I	207
12 C	8,[76-78]	4 F	17,28,197	23 I	27,141
13 C	71,72	5,7-9 F	1	25 I	27,206
14 C	7,137	6 F	18,28,33,195,198	1-25 K	210
15 C	205	10 F	17,28,58,94,199	1,2 K	2,4
16,17 C	1	11,14,16-22,24 F	1	3 K	16,166
18 C	97,98	12 F	8,79	4 K	1,18,19
19 C	1,8	13 F	28,200	5,8,9 K	1
20 C	110	15 F	28,33,[93-95], 143,198	6 K	1,18,19,195
21 C	97,110			7 K	208,209
22 C	1,8	23 F	17,28,[93-95]	10 K	1,18,19
23 C	8,100	1-3 G	1	11 K	18,75,139
24 C	1	4 G	1,[29-34]	12,14,15,17,19-22 K	1
25 C	204	5,7-9,11,12 G	1	13 K	83
1-3 D	1	6 G	[29-31],33,[58-60], 195	16 K	192
4 D	7,8,10,[20-22],26			18 K	174
5,7-9 D	1	10 G	1,[29-34],96	23 K	18,75,177,181
6 D	195	13 G	33,[35-37],133,144	24 K	111
10 D	7,8,10,[20-22]	14,16-22,24 G	1	25 K	18,206
11 D	22	15 G	[29-31],33,37,96	Fn 4-9,11-15, 17-22,24-35	196
13,15-17,19 D	1	23 G	[29-31],33,34,37, 95,96	Fn 10	[168-171]
14 D	7			Fn 16	70
18,20,21 D	138	1,2,5,7-9 H	1	Fn 23	172,173
22,24 D	1	3 H	15		
23 D	22,109	4 H	1,[29-34]		

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Other Important Contributions by: Babers, F. H.; Blackwood, A. C.; Blinks, L. R.; Burstrom, H.; Cantino, E. C.; Combs, G. F.; Danforth, W.; El Ani, E.; Elliott, A. M.; Evans, R. J.; Fogg, G. E.; Foster, J. W.; Gordon, H. T.; Hanson, R. W.; Haskins, R.R.; House, H. L.; Jennison, M. W.; Koser, S. A.; Ledingham, G. A.; Loefer, J. B.; Michelbacher, A. E.; Mills, R. C.; Moore, W. B.; Neish, A. C.; Noggle, G. R.; Noland, J. L.; Norris, L. C.; Pelletier, R. L.; Shu, Ping; Pomerene, E.; Shorb, M. S.; Simpson, F. J.; Steinberg, R. A.; Tatum, E. L.; Turrell, F. M.; van Wagtendonk, W. J.; Vishniac, H. S.; Wolf, F. T.

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7. NUTRIENTS: GENERAL NITROGEN SOURCES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-23 B	14,193,601,612, 659, [763-765]	17 B	157,612,640,657, [744-746]	15 C	[2-4],45,51,75,80, [86-93],586
1 B	165,601,612,639, [763-765],[796-799],828	18 B	378,612,649,745	16 C	[2-4],21,24,[31-34],[46-48],[51-60],103,104,331, 349,352,586,587, 603
		19 B	649,650,659,745		
		20 B	658,746		
2 B	14,176,334,601, 612,762,773	21 B	601,640,645,646, 649,657,659,744		
3 B	101,157,601,612, 643,651,665,[738-742],748,[753-761],763,765, 768,772,[774-785]	22 B	601,640,[645-650], 657,659,744,845	17 C	[2-4],32,34,48,[52-54],[61-65],[69-71],331,586,587
		23 B	659,660		
		1-23 C	2,3,4,16,193	18 C	[2-4],51,52,[61-68],299,331,586
		1 C	[2-5],16,18,23,24, 26,47,48,51,52, 56,57,331,[588-595]	19 C	[2-4],72,73,287, 288
5 B	101,765			20 C	1
5 B	101,157,601,612, 652,743,750,751, 765,[786-788]	2 C	[2-16],23,51,129, 257,258,351	21 C	[2-4],21,96,586
				22 C	[2-4],21,[96-100], 103,586
6 B	101,157,601,612, 643,652,[738-742],[753-761], 763,[765-771], [781-783],785, 794,[796-799], 826	3 C	[2-4],[16-21], [25-30],[32-35], 37,42,[45-47], 102,106,331,586, 825	23 C	[2-4],95,103
				1-23 D	23,193,587
				1 D	112,[732-736],800, 820,
		4 C	42,49	2 D	129,733
		5 C	[2-4],17,[38-40], 42,51,94,102, 825	3 D	732,800,806,808, [811-813],818, [822-824],831
7 B	101,612				
8,9 B	653,654				
10 B	612,794,795	6 C	[2-4],16,17,19, 20,25,[27-31], 34,[36-38),42, 45,51,102,124, 331,353	4 D	1
11 B	157,175,765			5 D	800
12 B	601,655,789			6 D	124,732,[800-802], 805,806,[820-823]
13 B	1				
14 B	157,601,612,[744-746],790				
		7 C	42,49	7,8 D	1
15 B	157,601,612,652, 738,744,745, 791,793	8 C	50	9 D	266,809
		9 C	267	10,11 D	1
		10 C	20,268	12 D	76,286,806
16 B	157,165,601,612, [641-644),649, 656,659,742, [744-749),764, 789,790,792,793	11 C	[2-4],[38-42]	13 D	286
		12 C	2,[75-79]	14 D	74,286,587,732,803, 806,810,820, [822-824]
		13 C	1		
		14 C	[2-4],[32-34], [80-85),114,587		

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Data Coordinates and Footnotes	Contributors and References
15 D	124,286,807,810, 816,817,820, [822-824]
16 D	74,111,113,126, [300-308],587, 732,737,800,803, 806,[811-816]
17 D	121,587,732,800, 806,820,822,823
18 D	587,732,800
19,20 D	1
21 D	105,[811-813],815
22 D	105,109,113,124, 286,697,715,807, [811-813],815
23 D	1
1-23 E	14,[124-126],193, 197
1 E	14,[124-126],197
2 E	3,14,43,107,[124-128],136,149,150, 164,[167-173], [178-184],188, 256,[331-337], 351,585
3 E	3,43,44,[124-126], 186,187,[190-192],[194-199], 203,218,220,249, 322,[622-630], 633,686
4 E	49,107,632,666
5 E	3,43,107,[124-126],186,187, 198,252,253,626, 628,631,633, [671-674]
6 E	3,43,44,107,[124-126],[190-192], [195-198],[259-264]
7 E	1
8 E	265
9 E	272
10 E	124,[269-271]
11 E	3,43,44,107,158, 186,187,632
12 E	[124-126],203,[273-280]
13 E	124,126,189,273
14 E	[124-126],186,187, 189,[195-198], 213,273,285,678,
15 E	[124-126],186,187, 189,[195-197], [200-203],273, 285,[289-292], 678,[681-685]
16 E	[124-126],186,187, 189,193,197, 199,[203-213], [215-217],[221-250],273,[321-328],350,610, [678-680]
17 E	[115-126],193,199, 204,217,250,309, 310,343,675
18 E	[124-126],193,299, [310-320],[338-342],[675-677]
19 E	186,187,[200-202], 273,[293-297], 636,678
20 E	[124-126],219,273, 678
21 E	[124-126],186,187, 199,214,215,223, 250,273,329,350, [577-582],719, [723-727
22 E	110,186,187,[213-216],223,250, 273,274,298,330, 350,583,584,634, 635,678,[698-700],[715-722], 829,830
23 E	108,[281-284],321
1-23 F	130,133,134,140, [155-157],[160-163],193,596
1 F	130,133,134,140, 155,616,621,661, 662
2 F	[130-133],[136-140] 140],164,174,185, 256,371
3 F	133,134,[140-148], 151,152,155,157, [665-670],826
4 F	133
5 F	133,157,826
6 F	124,133,134,[140-148],157,159
7-10 F	1
11 F	157
12 F	133,155
13 F	1
14 F	133,155,157,619
15 F	124,134,155,157
16 F	[133-135],157, 193,[618-620]
17 F	133,155,193,[728-731]
18 F	193
19,22 F	155
20 F	1
21 F	166
23 F	130,135
1-23 G	140,153,154,193, 374,378,410,417, 428,435,617
1 G	140,154,194,[354-356],374,410
2 G	133
3 G	133,140,153,[354-356],[364-371], 374,410,437, [665-670]
4,5 G	133
6 G	133,140,[354-356], [364-371],374, 435,437,599
7-13 G	1
14 G	354,374,435,437, 447,638
15 G	437
16 G	193,354,355,[357-359],364,365, 373,374,410,435, 442,463,617
17 G	193,[355-358], 374,410
18 G	193,370,374,412, 413
19 G	1
20 G	447
21 G	354,363,442,443, 452,455,463,617
22 G	441,698
23 G	599
1-23 H	153,193,374,409, 410,417,426, 428,608,609,617
1 H	193,374,[383-394], 410,428
2 H	1
3 H	372,374,375,377, 410,428
4 H	1
5 H	375
6 H	140,153,363,374, 375,410,428
7 H	1
8 H	374
9-13 H	1
14 H	354,374,[360-362], 435,447
15 H	377,426,437
16 H	193,354,[360-362], 374,376,377,382, [407-411],[415-421],[424-426], [428-436],439, 445,446,608,609, 663
17 H	193,374,[379-381], [383-394],406, 409,410,[422-424],428,436,446, 464,609
18 H	193,[395-405],409, 410,414,609,663
19 H	1
20 H	374,409,431,436, [449-451],461, 469
21 H	363,374,381,409, 410,426,428,436, [438-440],444, 445,453,454, [456-462],[465-468],617
22 H	374,409,410,[426-428],436,[438-440],444,445, [465-470],698, 701,702
23 H	1
1-23 I	193,471,472,516
1 I	[471-474[,[476-478],[501-503], 516,616
2 I	[504-508]
3-7 I	1
8 I	472
9-13 I	1
14 I	509
15 I	1
16 I	471,[480-488], 516,614
17 I	475,481,484,485, 488,512
18 I	471,[475-481],488, [509-516]
19 I	1
20 I	471,472,485,489, 490,[494-496]
21 I	471,472,484,485, [489-495],[497-499]
22 I	484,498,499
23 I	500
1 J	516
1-23 K	193,519,520, [604-607]
1 K	519,520,597,687

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Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References
2 K	1	16 K	193,519,[524-528], [530-534],[537-547],549,664,690, 691	20 K	519,565
3 K	[550-553],567, 637,688			21 K	519,[561-564], [565-567],[572-574],576,[703-712]
4-7 K	1				
8,9 K	519	17 K	193,525,[535-537], 547],549,664,690		
10-13 K	1			22 K	519,[561-564],[566-571],[694-696], 711,713,714
14 K	519,553	18 K	193,[521-523],548, 575,598,664,688, 690		
15 K	596,597,600,602, 611,613,689, 690,692,693			23 K	517,518
		19 K	519,[555-560]	Footnote 4 to 48	832

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Other Important Contributions by: Babers, F. H.; Beeson, W. M.; Berg, C. P.; Bird, H. R.; Blackwood, A. C.; Boone, D. M.; Burris, R. H.; Burstrom, H.; Cantino, E. C.; Combs, C. F.; Danforth, W.; Daniel, L. J.; Dewey, V. C.; Doyle, W. L.; El Ani, A.; Elliott, A. M.; Evans, R. J.; Fogg, G. E.; Foster, J. W.; Frenkel, A. W.; Goldsmith, G. A.; Gordon, H. T.; Hagen, K. S.; Hagman, N. C.; Hanson, R. W.; Haskins, R. H.; Henderson, L. M.; Hibbs, J. W.; House, H. L.; Jennison, M. W.; Jones, A. K.; Koser, S. A.; Kratzer, F. H.; Leben, C.; Ledingham, G. A.; Loefer, J. B.; Mac Vicar, R.; McCashland, B.; Mayer, J.; Michelbacher, A. E.; Mills, R. C.; Moore, W. B.; Neish, A. C.; Noggle, G. R.; Noland, J. L.; Norris, L. C.; Pace, D. M.; Paretsky, D.; Pelletier, R. L.; Phinney, B. O.; Shu, Ping; Pomerene, E.; Porges, N.; Proctor, B. E.; Provasoli, L.; Purvis, E. R.; Reid, M. E.; Rusoff, L. L.; Scheer, B. T.; Scott, M. L.; Shorb, M. S.; Silides, D.; Simpson, F. J.; Steinberg, R. A.; Tatum, E. L.; Thomas, J. W.; Thorne, R. S. W.; Turrell, F. M.; van Wagtendonk, W. J.; Vishniac, H. S.; Wolf, F. T.; Yanofsky, C.

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8. NUTRIENTS: GENERAL CARBON SOURCES

Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References
1-15 B	1,2,3	1-15 E	[8-11]	1-15 R	[13-16]
1-15 C	4,5,6	1-15 F	12	1-15 I	17,18
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9. NUTRIENTS: SULFUR SOURCES

Data Coordinates and Footnotes	Contributors and References
1-28 B	24,38,40,41,[43-45],47,50,62,63,[68-71],81,83,86,103,124,127,219
1 B	24,41,42,59,61,86,103,106,117,120,275,276,282
2 B	24,49,[52-54],57,60,[65-67],74,77,81,89,[101-104],110,126,282,339
3 B	208,219,282
4 B	25,41,61,65,282
5 B	208,282
6 B	38,39,61,65,89,90,109,114,116,119,120,282
7 B	26,27,41,42,46,48,51,57,61,66,67,74,77,79,[81-83],[87-89],[101-103],119,120,128,219,282
8 B	28,61,89,282
9-12 B	208,282
13 B	29,61,121
14 B	61,282
15 B	208
16 B	61,245,282,329
17 B	30,31,61,245,282,329
18,19 B	208,282,329
20 B	32,245,282,329
21 B	33,245,282.329
22 B	34,282,330
23 B	208,330
24 B	35,79,282,331
25 B	36,282,330
26 B	208,282,330,336
27 B	208,282,331
28 B	28,37,61,121,282
1-28 C	[1-3],93,257
1 C	[1-11],113,190,265
2 C	1,4,10
3 C	1,10,11
4 C	1,[5-8],10,211,265
5 C	1,[5-11]
6 C	1,[5-10],265
7 C	1,3,[5-11],93,211
8 C	1,10,11,265
9 C	1,10,11
10 C	10,265
11 C	1,10
13 C	1,11
14 C	1,[5-10]
15 C	1,[19-21]
16 C	1,3,[5-8],22,257,279,282,329
17 C	1,3,[5-8],10,11,14,257,279,282,329
18 C	1,10,20,21,329
19 C	1,3,10,329
20 C	1,10,13,19,22,[151-153],211,254,257,264,279,282,329
21 C	[1-3],22,279,282
22 C	1,2,23,258,330
23 C	208,330
24 C	24,331
25 C	[1-3],10,279,330
26 C	1,10,330
27 C	208,331
28 C	1,3,[5-10],[15-18],265,282
1-28 D	118,266
1 D	118,190,266,267,314
2 D	12
4,5 D	266,267
7 D	12,118,266,267,314
8 D	194,266,267
16 D	22,118,266,267,282,329
17 D	12,118,266,267,282,329
20 D	22,118,[266-268],282,329
21 D	12,282,329
22 D	266,267,282,330,340
23 D	208,330
24 D	22,266,267,331
25 D	266,267,330
26 D	282,330
27 D	208,331
28 D	12
1-28 E	179,180,183,187,[190-192]
1 E	55,56,78,105,111,112,[190-193],199,209,210
2 E	56,72,73,78,84,91,[94-96],108,123,125,161,[178-180],[199-202],210,[247-249]
3 E	149,208
4 E	55,56,78,105,111,112,[178-186],193,[195-199],201,207,210
5 E	208
6 E	78,190,199,205
7 E	55,56,78,105,111,112,[163-177],191,193,199,204,206,249,335
8 E	72,84,85,94,[178-180],[199-201.,210,[336-338]
9 E	208
10 E	162,[178-180],199,200,332,333,
11,12 E	199,205
13 E	190
14 E	208
15 E	190,191
16 E	56,78,107,111,112,212,313,329
17 E	55,56,107,111,112,144,147,148,193,329
18,19 E	[190-192]
20 E	111,112,[144-148],193,313,329,334
21 E	200,203
22 E	212,330
23 E	330
24 E	149,331
25,26 E	330
27 E	331
28 E	55,56,78,313
1-28 F	215,218,220,242,244
1 F	97,190,215,220,242,244,277,282
2 F	216,217,220,282
3 F	282
4 F	213,214,216,217,242,282
5 F	282
6 F	214,282
7 F	97,215,218,220,242,277,282
8-14 F	208,282
15 F	208
16 F	245,282,329
17 F	208,282,329
18,19 F	208,282
20 F	245,282,329
21 F	243,282,329
22 F	208,282,330
23 F	208,330
24 F	208,282,331
25,26 F	222,330
27 F	208,282,331
28 F	208,282
1-28 G	[223-226]
1-6 G	208
7 G	[223-226]
8-15 G	208
16,17 G	[223-226],329
18,19 G	208
20 G	221,[223-226],306,329
21 G	[223-226],329
22 G	221,306,330
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24 G	331
25 G	246,306,312,330
26 G	246,330
27 G	208,331
28 G	208
1-28 H	[223-226]
1 H	[223-226],231
2-6 H	208
7 H	[223-227]
8-14 H	208
15 H	223,228,233,294,313
16 H	[223-228],231,313,329
17 H	[223-228],231,234,305,313,329
18 H	228,231,232,313
19 H	223,[229-231,309,313
20 H	223,224,229,231,[235-238],305,308,310,311,313,329

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Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References	Data Coordinates and Footnotes	References
21 H	[223-226],[316-321],329	21 I	260	15 K	233,269,287,294
22 H	305,330	22 I	330	16 K	269,287,296,297,[299-301],329
23 H	208,330	23 I	208,330		
24 H	227,239,331	24 I	150,[260-263],331	17 K	76,92,98,[135-143],269,[287-292],[299-302],329
25 H	223,224,226,228,231,305,307,308,312,318,[322-324],330	25 I	330		
		26 I	208,330		
		27 I	208,331	18 K	269,287,[296-298],303
		28 I	208		
26 H	223,224,226,[325-328],330	1-28 K	[98-100],269,[283-287]	19 K	134,158,159,269,287,303,304
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27 H	223,224,228,237,240,241,308,331	2 K	58,80,115,[247-249],255,256		
28 H	208	3 K	208	21 K	269,329
1-28 I	260,341	4 K	160,188,189,315	22 K	269,330
1 I	260,341	5,6 K	208	23 K	330
2-6 I	208	7 K	64,[249-253],256,278,280,281	24 K	269,287,296,297,331
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8-14 I	208	8 K	287	26 K	208,330
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16 I	259,260,329	13 K	208,287,293	28 K	92,313
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20 I	259,260,[271-274],329				

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10. UTILIZATION OF CHEMICAL ELEMENTS: INSECTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
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Fn 3	25a,26c	6 J	10b	3 P	19b
2,17 B	1b	2,4,8,10,11,17-19 K	11b,12b	12 P	20b
8 B	2b	5 K & Fn 8	11b	2,8,10,17,18 Q	21a
6 C	3b	16 K	11b,12b,13b	2,4,8,10,16,17,18, 19 R & Fn 6,12	22a
16 D	4a	16 L	14a	1,2,9,10,12,13,17 20,21 S	23a
6,21 E	5a	2,10,11,16 M & Fn 10	15b	8 T	24a
8 F	6b	8 M	16b	Fn 5	b
9 G & Fn 9	7a	2,18 N & Fn 4	17a		
18 H	8b				

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11. UTILIZATION OF PROTEINS: INSECTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 A	a	2 G	32b	Fn 4 for 5,6 J	a
Fn 1	a	3 G	9a,10a,11a	8,12,14,15 J	4c,21c,24c
2 E G J	32b	Fn 3 for 3 G	a	Fn 8 for 8,16 J	c
Fn 2	b	4 G	32b	Fn 3 for 12,14 J	c
1,3,6,7,9,11,12, 16 B	12a,13a,14a	Fn 4 & 5 for 4 G	b	Fn 4 for 15 J	c
Fn 3 for 3,6 B	a	6,10,12-16 G	32b	1 K	15ac,16ac
Fn 8 for 16 B	c	Fn 3,4,5, & 8 for 6,10,12-16 G	b	3,16 K	15a,16a
1,3 C	2c	1 H	3c	6,7,9,12 K	15c,16c
Fn 3 for 3 C	c	3 H	1a,3a	Fn 8 for 6,7,9, 12,16 K	c
1,12 D	3c	Fn 3 for 3 H	a	1 L	3c,26c
3 D	1a,3a	1 I	3c	3 L	8a,26a,27a
Fn 3 for 3 D	a	3 I	1a,3a	Fn 3 for 3 L	a
Fn 3 for 12 D	c	Fn 3 for 3 I	a	3 M	28a
1 E	3c,6c,7c	1 J	4c,20a,21ac,22a, 24c	Fn 3 for 3 M	a
2-10,12-15 E	32b			3 N	29a,30a
3,9 E	3a,5a,6a,7a,8a,9a	3,5,6,9,16 J	20a,21a,22a,23a, 24a	Fn 4 for 3 N	c
Fn 3 for 3,9 E	a			1 O	17c,18c,19c,31c
16 E	3c,6c,7c	Fn 3 for 3,9 J	a	3,7 O	17a,18a,19a
Fn 4 for 16 E	c	2,4,7,10,13 J	32b	Fn 3 for 3 O	a
1 F	3c	Fn 3 for 2 J	b	Fn 8 for 7 O	a
3 F	1a,3a	Fn 4 for 4 J, 10 J	b	3 P	25a
Fn 3 for 3 F	a	Fn 3 for 7 J, 13 J	b	Fn 3 for 3 P	a

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References: (1) Fraenkel, G. and Blewett, M., Biochem. J. 37:686, 1943. (2) Moore, W., Ann. Ent. Soc. Am. 39:513, 1946. (3) Fraenkel, G. and Blewett, M., J. Exp. Biol. 20:28, 1943. (4) Fraenkel, G., Blewett, M., and Coles, M., Physiol. Zool. 23:92, 1950. (5) Fraenkel, G. and Blewett, M., Trans. Ent. Soc. London 93:457, 1943. (6) Chapman, R. N., J. Gen. Physiol. 6:565, 1924. (7) Chiu, S. F. and McCay, C. M., Ann. Ent. Soc. Am. 32:164, 1939. (8) Fraenkel, G. and Blewett, M., Nature 151:703, 1943. (9) Ibid., Biochem. J. 37:692, 1943. (10) Fraenkel, G., Reid, J. A., and Blewett, M., Biochem J. 25:712, 1941. (11) Gay, F. J., J. Exp. Zool. 79:93, 1938. (12) McCay, C. M., J. Biol. Chem. 100:67, 1933. (13) Melampy, R. M. and Maynard, L. A., Physiol. Zool. 10:36, 1937. (14) Noland, J. L. and Baumann, C. A., Ann. Ent. Soc. Am. 44:184, 1951. (15) Beck, S. D., Lilly, J. H., and Stauffer, J. F., Ann. Ent. Soc. Am. 42:483, 1949. (16) Bottger, G. T., J. Agr. Res. 65:493, 1942. (17) Begg, M. and Robertson, F. W., J. Exp. Biol. 26:380, 1950. (18) Lafon, M., Ann. Physiol. Physiochem. Biol. 15:215, 1939. (19) Shultz, J., St. Lawrence, P., and Newmeyer, D., Anat. Rec. 96:540, 1946. (20) Fraenkel, G., Proc. Biochem. Soc. 260:16, and Biochem. J. 42:1, 1948. (21) Fraenkel, G. and Blewett, M., Nature 157:697, 1946. (22) Ibid., Biochem. J. 41:469, 1947. (23) Fraenkel, G., Blewett, M., and Coles, M., Nature 161:981, 1948. (24) Lafon, M.,and Teissier, G., C. R. Soc. Biol. 131:75, 1939. (25) Trager, W., J. Biol. Chem. 176:1211, 1948. (26) Fraenkel, G. and Blewett, M., J. Exp. Biol. 22:162, 1946. (27) Ibid., Biochem. J. 41:475, 1947. (28) Ibid., 1946 (unpublished). (29) Crowell, M. F. and McCay, C. M., Physiol. Zool. 10:368, 1937. (30) Fraenkel, G. and Blewett, M., J. Exp. Biol. 22:156, 1946. (31) Hinton, T., Noyes, D. T., and Ellis, J., Physiol. Zool. 24:335, 1951. (32) Printy, G. E. and Fraenkel, G. S. (unpublished).

(continued on the next page)

11. UTILIZATION OF PROTEINS: INSECTS (Concluded)

Reviewers: Ball, G. H.; Beck, S. D.; Clark, E. W.; Craig, R.; Fraenkel, G. S.; Hambleton, J. I.; Harvey, G. T.; Hassett, C. C.; Hinton, T.; House, H. L.; Lawton, A. H.; Noland, J. L.; Printy, G. E.; Stauffer, J. F.; Trager, W.; Villee, C. A.

12. AMINO ACID REQUIREMENTS: MAN AND OTHER VERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-20 B	1h,2h	5,13 H	16f	Fn 1-4,10,16,19,20	h
1,2,5 20 C	Calc. fr 3	7 H	17f	Fn 6	a
1-3,5,6,7,19 DE	d	10 H	20f	Fn 7	f
8,10-14,17,18,20 D	10d,11d	12 H	13f,15f	Fn 9	19b
8 14,17,18,20 E	10d,11d	18 H	21f	Fn 11	e
2,8,10-14,17,18, 20 F	Derived from 5,6, 7,8,9 by c	2,8,10-14,17,18, 20 I	12g	Fn 12,13,15	g
		2,8,10-14,17,18, 20 J	18g	Fn 14	d
2,5,7,8,10-14,17, 18,19,20 G	a	2,8,10-14,17,18, 20 K	19b	Fn 17	g
2 H	14f			Fn 18	3e
				Fn 19	4

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References: (1) Adapted from values in Rose, W. C., Proc. Am. Philosophical Soc. 91:112, 1947. (2) Rose, W. C., Fed. Proc. 8:546, 1949. (3) Rose, W. C., Oesterling, M. J., and Womack, M. J., J. Biol. Chem. 176:753, 1948. (4) Adapted from Report of Committee on Animal Nutrition, National Research Council, March 1950. (5) Geiling, E. M. K., J. Biol. Chem. 31: 173, 1917. (6) Totter, J. R., and Berg, C. P., J. Biol. Chem. 123:cxxii, 1938. (7) Totter, J. R., and Berg, C. P., J. Biol. Chem. 127:375, 1939. (8) Bauer, C. D., and Berg, C. P., J. Nutrition, 26:51, 1943. (9) Maddy, K. H., and Elvehjem, C. A., J. Biol. Chem. 177:577, 1949. (10) Adapted from values in Steffee, C. H., Wissler, R. W., Humphreys, E. M., Benditt, E. P., Woodridge, R. W., and Cannon, P. R., J. Nutrition, 40:483, 1950. (11) Frost, D. V., and Sandy, H. R., J. Biol. Chem. 189:249, 1951. (12) Mabee, D. M., and Morgan, A. P., J. Nutrition, 43:261, 1951. (13) German, H. L., Schweigert, B. S., Sherwood, R. M., and James, L. E., Poultry Sci. 28:165, 1949. (14) Kratzer, F. H., Bird, H. R., Asmundson, V. S., and Lepkovsky, S., J. Nutrition 34:167, 1947. (15) Grau, C. R., Kratzer, F. H., and Asmundson, V. S., Poultry Sci. 25:529,1946. (16) Kratzer, F. H., Williams, D. E., and Marshall, B., J. Nutrition 37:377, 1949. (17) Kratzer, F. H., and Williams, D. E., J. Nutrition 35:315, 1948. (18) Morgan, A. F., Hunt, C. N., Arnrich, L., and Lewis, E., J. Nutrition 43:63, 1951. (19) Mertz, E. T., Beeson, W. M., and Jackson, H. D., Arch. Biochem. Biophys. 38:121, 1952. (20) Kratzer, F. H., J. Nutriton 47:631, 1952: (21) Kratzer, F. H., J. Nutrition 43:223, 1951.

Reviewers: Almquist, H. J.; Beeson, W. M.; Berg, C. P.; Csonka, F. A.; Fenton, P. F.; Frost, D. V.; Geiling, E. M. K.; Hill, C. H.; Kratzer, F. H.; Morgan, A. F.; Nestler, R. B.; Norris, L. C.; Rose, W. C.; Taylor, M. W.; Totter, J. R.; Womack, M.

13. AMINO ACID REQUIREMENTS: INSECTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1	b	6 D & Fn 2 & 5	8b	4,5,6 H & Fn 4	c
1,3,5,8-11,14,15, 16,19 B	3d	1,3,5,6,8,15-17, 19 D	6bd,8b	9 H	13b,15b,18c
2,4,6,7 B	1abd,2a,4f	2,4,9,10,12,14, 20 D	6bd,8b,4f	10,12,14,17,19, 20 H	15c,18c
12 B	1abd,2ade,4f	7 D	9a	16 H & Fn 8	15bc
Fn 6	d	11,18 D	6bd,8b,7d,4f	18 H	13bd,14d,15b,18c
15,16 B & Fn 7	d	4 E	10ad	1,3,5,6,8,15,16, 19 I	16d
17 B	2e,3d	11,18 F	11d	2,4,7,9-12,14,17, 18 I	16bd,4f
18 B	1abc,2ad,3d,4f	4 G	12d	20 I	16b
20 B	1ad,2a,4f	1,3,8,15 H	13b,15bc	1-12,14,15,16,17, 18,19,20 J	17d
1-12,15,17,18,19, 20 C	5abd	2 H	13bd,15b,18c	Fn 9	f
13 C	5ad	Fn 3	15b		
14,16 C	5bd	7,11 H	13d,18c,c		

Contributors: (a) Beck, S. D. (b) Fraenkel, G. (c) Hinton, T. (d) House, H. L. (e) Noland, J. L. (f) Trager, W.

References: (1) House, H. L., Canad. Ent. 81:133, 1949. (2) Noland, J. L. and Baumann, C. A., Ann. Ent. Soc. Amer. 44:184, 1951. (3) Hilchey, J. D., Cornell University, Ithaca, N. Y., (unpublished). (4) Roeder, K. D. (Ed), Insect physiology, New York: John Wiley & Sons, Inc. (5) Moore, W., Ann. Ent. Soc. Amer. 39:513, 1946. (6) Lemonde, A. and Bernard, R., Canad. J. Zool. 29:80, 1951. (7) Fraenkel, G., Biochem. J. 43:xiv,1948. (8) Printy, G. E. and Fraenkel, G., (unpublished). (9) Offhaus, K., Zeit. vergl. Physiol. 27:384, 1940. (10) Gay, F. J., J. Exp. Zool. 79:93, 1938. (11) Leclercq, J., Experientia 4:436, 1948. (12) Michelbacher, A. E., Hoskins, W. H. and Herms, W. B., J. Exp. Zool. 64:109, 1932. (13) Lafon, M., Ann. de Physiol., et de physiochem. Biol. 15:215, 1939. (14) van t' Hoog, E. G., Z. Vitaminforsch 4:300, 1935. (15) Hinton, T., Noyes, D. T. and Ellis, J., Physiol. Zool. 24:335, 1951. (16) Goldberg, L. and De Meillon, B., Biochem. J. 43:379, 1948. (17) House, H. L., (unpublished). (18) Rudkin, G. T. and Schultz, J. Anat. Rec. 99:613, 1947.

Reviewers: Ball, G. H.; Beck, S. D.; Clark, E. W.; Craig, R.; Fraenkel, G. S.; Hambleton, J. I.; Harvey, G. T.; Hassett, C. C.; Hinton, T.; House, H. L.; Lawton, A. H.; Noland, J. L.; Trager, W.; Villee, C. A.

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,6,10,12,13,19, 21,37,38 B	1f	38 L	15b,16b,17df,18d, 19d,20g	35 HH Fn 9	20g,27acdef,28acde d
41 B	ac	1,38 M & Fn 6	10e	36 BB	20g,27acf,28ac
1,6,17,19 C	2e	13,37,38 NO	11f	2,3,5,8-14,17,19,20, 21,23,24,25,29,	
7,37,38 C	2cf	1,6,10,13,19,21, 37,38 P	12b,13b,14b	32-36,38,39,40 CC	30e
13 C	b	1 Q	11ac	1,37,38 DD	31e,32e
1 D	3ace	6 Q	21f	1,3,5,7,9,10,12,13,	
7,12,13,15,37 D	3acef	13,37,38 Q	11f	19,21-24,32,33,	
18,40 D	3acf	1,13,37 R	22ace	38-40 EE	33e
41 D	3f	10 R	22ac	10 FF	34ac
1 E	4b	1,13,37 S	22ace	1,2,4 GG	35b,36e
1,13,37 F	5b	10 S & F 5	22e	3 GG	e
38 F	5bdef	1,13,37 T & Fn 7	23e	10,13 GG	20g,35abcef,36e
1 G	5abcdef,6abcde,7d, 8f	1 U	11e	5 GG	20g,35ac
3,4,5,7,10,18,19, 21,22,23,25,32,		13,37,38 U	11ef	7,9,12,15,17,18,19, 21-25,32-40 GG	20g,35abcef
33,35,40 G	5d,6d,7df	1,10 V	22b	8,11,14 GG	35abcef
12 G	7f	13,37 V	22abcdef	29 GG	35ac
13,37 G	5abcdf,6abcde,7df	7,12,18,19,21,22, 29,32,35,36,38,		1 HH	37b,38ace
38 G	5bdf,6abcde,7df	40 V	46d	3,33,35,36 HH	38ef
29,36 G	46d	1,13,37 W	22b	5,10,12,19,21,22,	
1 H	5abcdef	10 W & Fn 5	22e	23,32,39,40 HH	38acef
3,6,10,12,18,19, 21,22,23,29,32,		1,37 X	24acde	8 BB	38ace
35,36,38,40 H	46d	Fn 8	24ac	13 HH	38acef.39f
13,37 H	5be	13 X	24b	27 HH	38e
1,37,38 I	9ace	17 X	24e	29 HH	38acf
13 I	9e	Fn 5	24ac	37 HH	38ac
6,16 I	12ac	1 Y	25e	38 HH	37b,38ef
1,37 J	5b	13,37 Y	25f	1,11,18,29,35,38 II	40b,41b,42b,43b,44b
13 J	5abcef	38 Y	25ef	14 II	e
3,6,7,10,12,18,19, 21,22,23,29,32,		1,13 Z	26f	3,10,25 II	20g,42bf,43b,44b
35,36,38,40 J	46d	1 BB	20g,27acdef,28acde, 29ac	5,13,19,21,23 II	20g,42bde,43bdef, 44bdef
1,37 K	5cde	3,9,10,12,13,19, 21,22,24,33,		7,39 II	20g,42bde,43abcdef, 44abcde
13 K	5e	38-40 BB	20g,27acdef,28acde, 29ac	8,9,17,22 II	20g,42bde,43bdef, 44bde
1,37 L	15b,16b,17df,18d, 19d	5 BB	e	12,24,32,33,40 II	20g,42bde,43abcdef, 44abcdef
3,12,13,15,18,19, 40 L	16abcde,17df,18d, 19d,20g	7 BB	20g,27acdef,28de	36 II	20g,44f
		8 BB	e	37 II	20g,41abcde,42bde, 43abcdef,44abcde
8 L	19d	11 BB	27def,28acde		
5,23,29,30,35 L & Fn 4	17ad,18d,19d	14 BB	27e,28e	41 II	43ac
10,22 L	15b,16b,17ad,18d, 19d,20g	20 BB	e	Fn 3	d
16 L	15b,16b,17d,18d, 19d	15,17,18,23,25, 32,37 BB	20g,27acdef,28de, 29ac	1 JJ	45ac
21,32,34,36 L	16d,17df,18d,19d	26,27,28,30,31 BB	27e,28e	7,10,12,13,15,19 21,24,37,38,	
		29 BB	27acdef,28acde, 29ac	39 JJ	45acf

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References: (1) Cook, S. F., Physiol. Zool. 16:123, 1943. (2) Noland, J. L., Lilly, J. H., and Baumann, C. A., Ann. Ent. Soc. Amer. 42:154, 1949. (3) Brown, A. W. A., Bull. Ent. Res. 28:333, 1937. (4) Moore, W., Ann. Ent. Soc. Am. 39:513, 1946. (5) Fraenkel, G., and Blewett, M., J. Exp. Biol. 20:28, 1943. (6) Chiu, S. F., and McCay, C. M., Ann. Ent. Soc. Am. 32:164, 1939. (7) Bernard, R. and Lemonde, A., Revue Canad. de Biol. 8:498, 1949. (8) Leclercq, J., Arch. Inter. Physiol. 56:28, 1948. (9) Parkin, E. A., Ann. Appl. Biol. 23:369, 1936. (10) Larson, A. W. and Fischer, C. K., J. Agr. Res. 29:297, 1925. (11) Evans, A. C., Trans. Roy. Ent. Soc. Lond. 89:13, 1939. (12) Beck, S. D., Physiol. Zool. 23:353, 1950. (13) Beck, S. D. Lilly, J. H., and Stauffer, J. F., Ann. Ent. Soc. Am. 42:483, 1949. (14) Bottger, G. T., J. Agr. Res. 65:493, 1942. (15) Evans, A. C. and Goodliffe, E. R., Proc. Roy. Ent. Soc. Lond. 14:57, 1939. (16) Lafon, M. and Teissier, G., C. r. Soc. Biol. 131:75, 1939. (17) Leclercq, J., Arch. Inter. Physiol. 56:130, 1948. (18) Fraenkel, G., Blewett, M., and Coles, M., Physiol. Zool. 23:92, 1950. (19) Fraenkel G. and Barker E., (unpublished). (20) Roeder, K. D. (Ed.), Insect physiology, New York: John Wiley & Sons, Inc., 1953. (21) Evans, A. C., Proc. Roy. Ent. Soc. Lond. 14:25, 1939. (22) Fraenkel, G. and Blewett, M., J. Exp. Biol. 22:162, 1946. (23) Brown, F. M., Ann. N. Y. Acad. Sci., 32:221, 1930. (24) Fraenkel, G. and Blewett, M., J. Exp. Biol. 22:156, 1946. (25) Crowell, H. H., Ann. Ent. Soc. Am. 34:503, 1941. (26) House, H. L. (unpublished). (27) Fraenkel, G., J. Exp. Biol. 17:18, 1940. (28) Haslinger, F., Z. vergl. Physiol. 22:614, 1936. (29) Fraenkel, G., Nature 137:237, 1936. (30) Hassett, C. C., Dethier, V. G., and Gans J., Biol. Bull. 99:446, 1950. (31) Glaser, R. W., J. Exp. Zool. 38:383, 1923. (32) Vinokurov, S. I., Memorial Publ. for V. G. Korolenko Kharkov, 74, 1922. (33) Baker, A. C., Stone, W. E., Plummer, C. C., and McPhail, E., U.S.D.A. Misc. Publ. 531, 1944. (34) Levenbook, L., Nature 160:465, 1947. (35) Hassett, C. C., Biol. Bull. 95:114, 1948. (36) Guyenot, E., Bull. Biol. Fr. Belg. 51:1, 1917. (37) Trager, W., J. Biol. Chem. 176:1211, 1948. (38) Wigglesworth, V. B., J. Exp. Biol. 19:56, 1942. (39) Golberg, L. and DeMeillon, B., Biochem. J. 43:372, 1948. (40) Haydak, M. R., J. Econ. Ent. 28:657, 1935. (41) Ibid., Ann. Ent. Soc. Am. 30:258, 1937. (42) Melampy, R. M. and McGregor, S. E., J. Econ. Ent. 32:721, 1939. (43) Phillips, E. F., J. Agr. Res. 35: 385, 1927. (44) Vogel, B., Zeit. vergl. Physiol. 14:273, 1931. (45) Bertholf, L. M., J. Agr. Res. 35:429, 1927. (46) Fraenkel, G., (unpublished).

Reviewers: Ball, G. H.; Beck, S. D.; Clark, E. W.; Craig, R.; Fraenkel, G. S.; Bambleton, J. I.; Harvey, G. T.; Hassett, C. C.; Haydak, M. H.; Hinton, T.; Rouse, H. L.; Noland, J. L.; Trager, W.; Villee, C. A.

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 H	1d,2d	34,36,37,40,42,44 G	10d	Fn 6 for 14 O	19a,20a,21a
8 B	1d	31,38 G	5c,10c,11c	Fn 5 for 18,19 O	5d
Fn 4 for 8 B	1d	1 H	5d	Fn 6 for 15,18 O	c
Fn 11 for 29 B	1d	Fn 1 for 1 H	5d	Fn 10 for 18 O	d
14,24,27,29,30,31, 33,34,35,40 C	3a,4a	14,24,26,29,30,40, 42 H	5a	Fn 6 for 19 O	5d
26 C	3c	Fn 2 for 29,30,40, 42 H	5d	Fn 2 for 29 O	5d,22d
32 C	3ac,4a	25 H	5acd,8c	Fn 2 for 30,33,42 O	5d
1 D	5d	44 H	5ad	15 O	8c,10d,20a,21acd
Fn 1 for 1 D	5d	Fn 12 for 44 H	5d	Fn 7 for 15 O	d
14,24,25,26,29,30, 40,42,44 D	5a	1 I	5d	Fn 8 for 15,16 O	8c,21c
Fn 2 for 29,30,40, 42 D	5d	14,24,25,26,29,30, 40,42,44 I	5a	16,38 O	8c,21c
Fn 12 for 44 D	5d	Fn 2 for 29,30,40, 42 I	5d	26,40 O	5d,8c,19a,20a,21ac
1 E	5d,6d	Fn 12 for 44 I	5d	31 O	5d,8c,21c
Fn 1 for 1 E	5d,6d	24,26,28,29,33,35, 41,42 J	32b	34 O	5d
9 E	5d	1 K	12d,13d,14d	1,6,7,9,10 P	19d
Fn 2 for 9,30,33, 40,42 E	5d	14,24,29 K	15a,16c	Fn 2 for 1,29 P	19d
24,25,29,30,33,34, 40,42 E	5a,7a	Fn 2 for 29 K	12d,13d,14d	Fn 1 for 9 P	19d
26 E	5acd,7ac,8c	25,40,41,42 K	14d	14,18,19,21,24,29 P	19a,22a
27 E	5ac,7ac,8c	Fn 2 for 40,41,42 K	14d	Fn 6 for 14 P	19a,22a
Fn 2,11 for 29 E	5d,9d	Fn 12 for 41 K	14d	Fn 5,6 for 18 P	19d
31 E	5cd,7c,8c	14,18,24,29 L	17a,18a	1,9 Q	23d
36,37,44 E	5ad,7a	Fn 6 for 14 L	17a,18a	14,24,29 Q	23a
Fn 12 for 37,44 E	5d	Fn 6 for 29 L	c	Fn 2 for 29 Q	23d
38 E	5c,7c,8c	1,6,7,9,10,18 M	19d	1,6 R	24d
1 F	5d	14 M	19b	24 R	25e
Fn 2 for 1,29,30, 33,40,42 F	5d	24 M	22b	28 R	24d,25d
14,24,25,28,29,30, 33,34,36,37,38, 40,42,44 F	5a	29 M	19d	Fn 2 for 29 R	24d,25d
26 F	5ad	Fn 2 for 1,29 M	19d	1,25,26,41,42,43,S	26d
31 F	5cd,8c	Fn 5,6 for 18 M	19d	14,24,29,40 S	27a,28a
1 G	10d	1,6,9 N	19d	Fn 2 for 29,40 S	26d
Fn 2 for 1 G	10d	14 N	19b	45 S	c
14,24,25,26,28,29, 33,34,36,37,40, 42,44 G	5a,10a,11a	24 N	22b	1,2,3,4,5,10,11,12, 13,17,18,19,20, 22,23,25,26,31, 39,40,42,43,44 T	29d
Fn 2 for 29 G	10d,11d	29 N	19d	Fn 1 for 1 T	29d
30 G	5c,10cd,11c	Fn 2 for 1,29 N	19d	Fn 3 for 4 T	e
Fn 12 for 30,31 G	10d	1,6,7,9,10 O	19d	Fn 2 for 10,42,43 T	29d
		Fn 2 for 1,9 O	19d	Fn 9 for 17,20 T	29d
		Fn 5 for 9 O	19d	14,24,29 T	30a,31a
		14,18,19,21,24,25, 28,29,30,33,36, 37,42,44 O	19a,20a,21a	Fn 2 for 29 T	29d
				21 T	29,31d
				Fn 3 for 21 T	e
				Fn 9 for 21 T	29d,31d

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1	g	16 I & Fn 10	12b	8 T	36acef
1,12,16 B	1b,2b,3b,4g	1,6,8,9,11-13,16 J	13ac	13 T	38e
3 B & Fn 4	1b,2b,3b	1 K	7e	16 T	36ac
6,11,13 B	1b,2b,3b	3 K	7abcde,8acde,9b, 10b	1 U.	39abcdeg
1,3,6-13,16 C	5b,6b			3,7-14,16 U	39b
1 D	7de,9d,10acd	7 K	7b,8de,10b	1,3,7-13 V	40ace
3,13 D	7abcde,8abcd,9abc de,10abcd,11abce	8-13 K	7b,8acde,10b	16 V	41e
		16 K	7b,8acd,10b,11b	1,6,8,9,11 W	4g,23aci,42b,43b, 44b
6 D	9d,10d	2 L	b		
7,8,10,12,16 D	7b,8b,9b,10b,11b	1,3,6-13,16 L	24d	2 W	23i
9 D	7abcde,8abcd,9abc de,10abcd,11abc	1,3,8,9,11-13,16 M	7b,8b,11b	3 W	4g,23d,42ace,43e, 44ae
		7,10 M	7b,8b,11b		
11 D	7bd,8bd,9bde, 10abcd,11be	1 N	26d,27d,28e	4 W & Fn 12	23ac
		2 N	b	7 W	4g,23ac,42abcdh, 43bdh,44abcdeh
1,3,7-13,16 E	7b,9b,10b,11b	3 N	12bd,25d,26d		
6 E	10acde	6,8,9,11-13 N	4g,13b,20b,25d, 26d,27d,29d,30b, 31b	10 W	23aci,42abcdh, 43bdh,44abcdh
1,3,8,9,11-13 F	4g,7b,8b,11ac, 12b,13b,15b,16b, 18b,19b			12,13 W	4g,23ac,42b,43b, 44b,45e,55c
		7,10 N	25d,26d,27d		
6 F	4g,7b,8b,12b,13b, 15b,16b,18b,19b, 20e	16 N	13b,20b,25d,26d, 27d,29b,30b,31b	14 W	h
				16 W	42b,43b,44b,55c
		3,16 O	32b	8,12,13,16 X & Fn 15	25ac,46ac
7,10 F	7b,8b,12b,13b,15b, 16b,17b,18b,19b	1,14,16 P & Fn 10	33ac		
		6 P & Fn 13	13ac	1,6 Y	4g,46b,47b,48b, 49b,51b,52ac
16 F	7abc,8abc,12abc, 13abc,14b,15b, 16abc,17abc, 18abc,19abc	1,3,7-13 Q	7b,13d,20b,33b,34b d	Fn 11	abcg
		5 Q		3,8,9,11-13 Y	4g,46b,47b,48b, 49be,51abc,52ac
		6 Q	7b,13acd,20ac		
		Fn 13	13ae	7 Y	4g,47abcd,48abc de,49bde,51bd
1 G	7e,9e,10ace,11e	14 Q	33a		
3,8 G	7abcde,8ace,9abcde, 10abcde,11abcde	16 Q	7abc,20abc,21d, 35abcde,36abc	10 Y	47abcd,48abcde, 49bde,51bd
6 G	10ac	11,12 R	35e,36f		
7,9-13,16 G	7b,8ace,9b,10b,11b	13 R	36f,37ace	14 B-I K MN PQRS U W Y & Fn 9	g
1,8,13,16 H	7b,9b,10b,11b	16 R	35e,37ac		
3 H	7bd,9bde,10abce 11abce	Fn 10	ac	15 N PQ S	4g,5g,51g
		1,3,8,9,11-13 S	11e,13d,33b,34b	16 Y	4g,46b,47b,48b, 49b,50b,51b
6 H	10e	6 S	13acde,34b		
7 H	7abce,9abcde, 10abcde,11abc	Fn 13	13ac	Fn 16	b
		7,10 S	13d,33b,34b	1-13,16 Z	53e
1,8,9,11-13 I	21d,22f	14 S	33a	8,16 BB	54b
3,6,7,10 I	21d	16 S	11e,13d,33abcde,34b	Fn 10	b
				12 BB	54ac

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17. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS: PROTOZOA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
15,16,19 B	1c	Fn 9	a	16,18 T	18c,19c,20c
16 C	2c,3c,4c	2,3,4,8,9,11-19 J	13c,34c	16,18 W	19c,20c,21c,22c
2,3,9,11-19 D	5c,6c,7c,8c	2,17,19 K	14c,15c	19 Y	23c
17,19 E	9c	2,18,19 L N	16c	2,17,19 Z	24c,25c,26c
8,15,16 F	31a,c	2,18 M	16c	2,17,19 BB	27c
19 F	10c,32c	2,18,19 O	16c,17c	2,19 CC	28c
Fn 5	c	18,19 P	18c	2,18,19 EE	17c
19 G	11c	18 Q UV X	19c	16 FF	29c
19 HI	12c	16,18 RS	19c,20c	13,19 GG	30c
		2 P-Y FF	b		

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18. CORRELATION OF NUTRIENT REQUIREMENTS WITH BODY WEIGHT, ENERGY METABOLISM, AND FOOD INTAKE: ANIMALS

Reference: Adapted and modified from tabular data in Mitchell, H. H., Scientia 85:165, 1950; contributed by Mitchell, H. H.

Reviewers: Darby, W. J.; Hathaway, M. L.; Mitchell, H. H.; van Eys, J.

19. CHEMICAL ELEMENT COMPOSITION OF NUTRIENT SOLUTIONS: HIGHER PLANTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-10,12-15 B	1a	1,2,4-10,12-15 D	2bc	Fn 6	d
1-15 C	1a	1,2,4-15 E	2bc	Fn 7	a

Contributors: (a) Arnon, D. I. (b) Bear, F. E. (c) Robbins, W. R. (d) Withrow, A. P.

References: (1) Hoagland, D. R., and Arnon, D. I., Univ. Calif. Agr. Exp. Sta. Circ. 347, 1950. (2) Robbins, W. R., modified from Soil Sci. 62:3, 1946.

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20. UTILIZATION OF CHEMICAL ELEMENTS: CORN PLANT

Data Coordinates and Footnotes	Contributors and References
1-15 B	1a,2a
Fn 1	1a,2a
1-15 C	Calc. fr 1-15 B

Contributor: (a) McVickar, M. H.

References: (1) Hambridge, C. (editor), Hunger signs in crops, Washington: Nat'l Fertilizer Assoc., 1949, p2. (2) Agr. and Home Economics Extension Service, Ill. Agricultural handbook, Urbana: Univ. Ill., 1949.

Reviewers: Clark, D. G.; Gauch, H. G.; Krantz, B. A.; McMurtrey, J. E., Jr.; McVickar, M. H.; Meyer, B. S.; Purvis, E. R.; Reuther, W.; Sayre, J. D.; Scarseth, G. D.; Volk, N. J.

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1,2,3	b	9,12 K	3b	26-37 P	5b,6b,11b,15b
1,2,3 B	1b,2b,10b	12-15 L	3b	26-30,32,35,37 Q	5b,6b,11b
1,2,3 C	1b,2b,5b	11,14 M	3b	26-30,32-37 R	4b,5b,6b,11b
1,2,3 DE	1b,2b	11,12,14,15 P	6b,11b	26-28,30,35,37 S	5b,6b,11b
1,2,3 F & Fn 5	2b,22b	11,14 Q	6b	26-37 T	5b,6b,16b
1 H	1b,8b	12,15 Q	11b	26,37 U	5b,6b,17b
2 H & Fn 7	1b,29b	11,12,14,15 R	6b,11b	26-37 VW	5b,6b,11b
1,2 IJ & Fn 6	1b,8b	11,12,14,15 S	11b	26-37 X	5b,6b,11b,18b,19b
1,2,3 K & Fn 5	2b,3b	11,14 T	6b,16b	26-37 Y	9b
2 L & Fn 8	1b,23b	9-13,15 U	6b,10b	Fn 16-20	b
1,2,3 M & Fn 5	1b,25b	14 U	6b	39,41,43,47,48 B	10b
1,2,3 N	1b,2b,10b	11,12,14,15 VW	6b,11b	39,41,47,48 C	25c
1,2,3 O	1b,27b	11,14 X	6b,11b	39,47,48 D	4b
1,2,3 P	1b	12,15 X	9b	39,41,47,48 E	4b,12b,21b
1,2,3 R & Fn 8	1b,2b,29b	9,10,11,14,15 Y & Fn 11	7b	39,47 F	21b,22b
2 T & Fn 9	b	Fn 12	b	38,40-46,48-54 F	3b
2,3 U	b	17-19 C	20b	38-54 GH	3b
2 V & Fn 9	b	18 D GH	5b,6b,13b	38,39,42,47,48 I	24b
2 W	ab	18 E PQRS WX	5b,6b,11b	39,42,47,48 J	24b
3 W	b	18 J TUV Y	b	38,54 K	3b
2 X & Fn 8	a	19 FG LM	3b	41 L	23b
2 Y & Fn 8	7b,a	19 Y	b	38-40,42-54 L	3b
4-8 C	20b	16,17,20-25 H P R & Fn 13	5b,6b	38-54 M	3b
4-8 DE R	4b,6b	17,20,21,25 Q	5b,6b	39,41,43,47,48 N	10b
5,7 FGH KL	3b	16,17,18,21,23-25 WX	5b,6b,	39,47,48 O	26b
5 I	24b,31b	20,22 X	5b,6b	42 O	27b
5 J P V	6b	16-19,21-25 Y	9b	39 P	28b
4,5,8 W	6b,18b	Fn 14	b	48 P	15b
5,6,7 X	6b,18b	26-28,30,35,37 B N	5b,6b,10b	48 Q	6b,11b
4-8 Y	9b	26,28,35,37 C	20b	39,47,48 R	29b
Fn 10	b	26-28,30,35,37 D	4b,5b,6b	48 S	18b
9,11-13,15 B N	6b,10b	26-28,30,35,37 E	4b,5b,6b,11b	41,48 T	30b
9-15 C	20b	26-28,30,32-37 FG L & Fn 15	3b	39,47 T	29b
11,12,15 E	6b,11b	26-37 H	5b,6b,11b,14b	38-41,43-52 U	10b
14 E	6b,12b	26-28 I	24b	38,46 V	a
9,11-15 F	3b	26-37 J	5b,6b	39,47 V	29b
9,12-15 G	3b	26,28,35 K	3b	48 V	11b
9,13 H	3b,6b	26,35 M	3b	38,39,44,45,47,48, 51,54 W	18b
11,14 H	6b			41,43 W	18b,a
12,15 H	6b,11b			39,47,48 X	29b
9-13,15 I	25b			39,48 Y	7b,9b
9,10,12 J	25b				
11,14,15 J	6b				

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Reviewers: Allen, M. B.; Elliott, A. M.; Hutchens, J. O.; Pringsheim, E. G.; Provasoli, L. A.; Schoenborn, H. W.

22. AMINO ACID REQUIREMENTS: BACTERIA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-20 B	1a,2a	21 P	17b	18,21 EE & Fn 7	8a,9a,10a
22 B & Fn 2	Inferred from (1-20 B)	1-20 QR	17b	21 FF	a
		22 QR & Fn 2	Inferred from (1-20 QR)	21 GG & Fn 8	11a
21 C	17b			5,21 HH	12a
21 D	18b,19b	1-21 ST & Fn 1	3a,4a	5 II	13a
21 E-I	17b	1-21 U & Fn 1	3a,4a	19,21 JJ & Fns 4,5	14a
1-20 JKL	17b	1-20 VWX & Fn 3	5a	18 KK & Fn 1	15a
22 JKL & Fn 2	Inferred from (1-20 JKL)	1-20 Y	1a,6a,7a	1-20 LL	1a,16a
		1-20 Z EE & Fn 6	5c	21 MM & Fn 8	a
21,22 M	17b	22 V-Y & Fn 2	Inferred from (1-20 V-Y)	1-21 NN & Fn 8	a
1-20 NO	17b			22 LL	Inferred from (1-20 LL)
22 NO & Fn 2	Inferred from (1-20 NO)	18,21 CCDD & Fn 7	8a,9a		
		21 Z BB JJ	a	22 NN	a

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Reviewers: Koser, S. A.; Smith, N. R.; Snell, E. E.

23. UTILIZATION OF SUGARS FOR GROWTH: FILAMENTOUS FUNGI

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-M	23b	31,32,33,34,35 B-M	7a	60,61 B-M	7a
2,3,4 B-M	7a	36,37 B-M	6a,9a	62 B-M	4b
5 B-M	14a	38,39 B-M	7a	63,64 B-M	6a,9a
6 B-M	15a	40 B-M	12ab	65 B-M	8b
7 B-M	7a	41 B-M	7a	66,67,68 B-M	6a,9a
8 B-M	6a,9a	42 B-M	10b	69 B-M	22b
9 B-M	4d	43 B-M	7a	70 B-M	23b
10,11,12,13,14,15 B-M	7a	44 B-M	19d	71,72 B-M	7a
		45 B-M	6a,9a	73 B-M	3d
15 B-M	1d	46,47,48 B-M	7a	74 B-M	11a
16,17,18,19 B-M	7a	49 B-M	20ad	75 B-M	6a,7a,9a
20 B-M	16a	50,51,52 B-M	7a	76,77 B-M	7a
21 B-M	23b	53 B-M	6a,7a,9a	78 B-M	6a,21a
22,23 B-M	9a	54 B-M	2d	79 B-M	6a,9a
24,25 B-M	7a	55,56,57 B-M	6a,9a	80 B-M	23b
26,27 B-M	17a	58 B-M	7a	81 B-M	6a,9a
28,29 B-M	7a	59 B-M	6a,9a	82 B-M	13d
30 B-M	7a,9a			Fn 1	24c

Contributors: (a) Barnett, H. L., and Lilly, V. G. (b) Cantino, E. C. (c) Fergus, C. F. (d) Wolf, F. T.

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24. UTILIZATION OF CARBOHYDRATES: YEASTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
6,22 B	1b	7 R	3b,4b,c	Fn 8 for 6 Y	1b
24 P	a	Fn 9 for 7,12,22 T	1ab	Fn 8 for 6 II	1b
Fn 1-5	1ab	Fn 8 for 11 X	a,1b	All other values	2,5,6c

Contributors: (a) Clark, F. M. (b) Etchells, J. L. (c) Wickerham, L. J.

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Reviewers: Clark, F. M.; Etchells, J. L.; Hartley, C.; Kaufert, F.; Wickerham, L. J.

25. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS) REQUIREMENTS: FUNGI

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B & Fn 1	111c	Fn 9,10 for 47 B	97a,98a	102 B	94a,118bc
2 B & Fn 2	12c,92c,109c,110c	48 B	95a,98a	103 B & Fn 10	53a,55c
3 B	50c	49 B	94a,137a	104 B	3c
4 B	49c	50 B	12c,49c,94a	105 B	94a,118c
5-7 B & Fn 3	3ac	51 B	54a,55c	106 B	23c,115c
8 B	3ac,125a	52 B & Fn 16	35c,55c,94c,118c	107 B	32b
9 B & Fn 4	88	53 B	12c	108 B	59b
10 B	127a	54 B & Fn 17	127a	109 B & Fn 25	90c
11 B & Fn 5	69b	55 B	95a	110 B	35c,94a
12 B	49c	56 B	55a,109c,110c	111 B & Fn 27	96ac
13 B	128c	57-61 B & Fn 10,17	53a	112 B & Fn 28	24a,27c,33c,50c,51c 55a,94a,137c
14 B	35c	62 B	48c,92c,94a	113 B	127a
15 B & Fn 6	35c,72c,73c	63 B	3a,41c	114,115 B	3c
16 B	103c	64,65 B & Fn 18	59b	116 B	126c,130c
17 B	28a	66 B & Fn 5	67bc,69b,70b	117 B	50bc
18 B	115c	67 B	55ac	118 B	55a,94a,103c
19 B & Fn 7	6c,17c,35c,41c,55a, 77c,81c,82c,87c, 94a,103c,121c	68 B	94a,134c	119 B	98a
		69 B & Fn 17	87c,127a	120 B	35c,94a
		70 B & Fn 17	55c,127a	121 B	43c
20 B	121c	Fn 10 for 70 B	127a	122,123 B	15c
21 B	55ac	71 B & Fn 19	59b	124 B	3ac
22 B	43c,94a	72 B	60b	125 B & Fn 29	24a,103c
Fn 1 for 22 B	49c	73 B & Fn 20,21	59b,62b	126 B	45ac
23 B	18ac	74 B & Fn 7,21	26b,49b,50bc	127 B	3c
24,25 B	3a	75 B	55ac	128 B	3a
26 B & Fn 8	66b,67c,69c,70c, 94a	76 B	39bc	129 B & Fn 27	3a,106c
		77 B	59b	130 B	3a
Fn 9 for 26 B	69b,70b	78 B	16c	131 B	3ac,16c
27 B	133c	79 B	82c	132 B	3a
28 B & Fn 10	53a	80 B	30c	133 B & Fn 30	30bc
29 B	19c,55a,94a,127a, 137c	81 N & Fn 23	48c,94a,109c,110c	134 B	35c,94a
		82 B	50bc,94a	135 B & Fn 31	59b
30 B	15c	83 B	23c	136 B	27bc,94a
31 B	30c	84 B	27bc,94a	137 B	27c,94a
32 B	30b	85 B & Fn 24	27bc,94a,127a	138 B	82c
33 B	123c	86 B	55ac	139 B	49c
34 B	13c	87 B	48c	140 B	13c
35 B	3c	88 B	13c,15c	141 B	30c
36 B & Fn 11	13c,15c,16c	89 B & Fn 25	3c,15c	142 B	67bc,70b,94a
37 B & Fn 12	13c,15c	90 B	50bc	143 B & Fn 10	35c,53a
38 B	118c	91 B	118c	144 B & Fn 10,32	53a,55c
39 B & Fn 1,10	68b,69b,70bc,71b	92 B & Fn 1	119c	145 B	30b
40 B	1c,3a	93 B	55ac	146 B & Fn 33	49bc,94a
41 B	127a	94 B	50c,94a	147 B & Fn 20,35	30b,31b,50bc,52ab, 94a
42 B	97c,98c	95 B	48c		
43 B & Fn 10	95a	96 B	94a,109c,110c	149 B	59b
44,45 B	98a	97 B	63c,94a	150 B & Fn 10	49ac
46 B & Fn 13	55a,97a,98a	98 B	50c,94a	151 B	3c
Fn 9 for 46 B	55a,97a	99 B	94a,133c	152 B	82c
Fn 14 for 46 B	97ac,98ac	100 B	3ac		
47 B & Fn 15	97ac.98ac	101 B	55ac		

(Continued on the next page)

Data Coordinates and Footnotes	Contributors and References
153 B	56bc,58a
Fn 10 for 153 B	57b
Fn 5 for 153 B	58b
154 B	56c
155 B	56bc,58abc,61b,108c
Fn 9,36 for 155 B	56b,58b
156 B & Fn 10	53a
157 B	94a
158 B	36c,94a
159 B	65c,85a
160 B	27bc,94a
161 B	3c,94a
162 B & Fn 37	3ac,131c
163 B	118c
164 B	16c
165 B	55c,127a
Fn 38	127a
166 B	45a
167 B	3a
168 B & Fn 7	92c,94a,109c,110c
169 B	109c,110c
170 B	94a,109c,110c
Fn 39 for 170 B	109c,110c
171 B & Fn 40	12c,35c,77c,92c, 94a,135c
172,173 B	29b
174 B & Fn 41,42	29b,32b,59b
175 B	69b
176 B	13c
177 B	16c
178 B	102c
179 B	48c
180 B	94a,118c
181 B	45a,55c
Fn 10 for 181 B	45a
182 B	25c
183 B	45a,115c
184 B	55a
185 B & Fn 43	16c,55a,94a
186 B	30bc,49b
Fn 1 for 186 B	30b,49b
187 B	30b
188 B	55a,129c
189 B	94a,107c
190 B	50c,94a
191 B	50c,55c,98a
192,193 B & Fn 10	28a
194 B & Fn 10	30bc
195 B	30b,59b
196 B	137c
197 B	94a,109c,110c
198 B	135ac
Fn 10 for 198 B	135a
199 B & Fn 44	2c,4c,7c,9c,10c, 20c,27c,40c,48c, 55ac,64c,76c, 87c,89c,94a,131c
200 B & Fn 45	30bc
201 B & Fn 10	83a
202 B & Fn 46	3a,16c,137c
203 B & Fn 10	94a,95b
204 B	59b
205 B	55ac,137c
206 B	45a,91c,108,109
Fn 47 for 206 B	91c
207 B	49c,94a
208 B	122c
209 B	49c,55a,91c,94a
Fn 48	49c,91c,92c
210 B	16c
211-213 B	15c
214 B	3a,137c
215 B	49c,94a,113c
Fn 1 for 215 B	49c,113c
216 B	94a,109c,110c
217 B	47a,55c
218 B	5c
219 B	55c,94a
220 B & Fn 1	49bc
221 B	55c
222 B	62bc,94a,95b,118b
223 B	27bc,30bc,45abc, 78b,86b,94a, 118bc,119c
Fn 50	27c,30c,45c,118bc, 119c
226 B & Fn 51	118c
225 B	124b
226 B	92b,94a,109c,110c
227 B	50c
228 B	44c
229 B	35c,94a
230 B & Fn 1	49c
231 B & Fn 51	12c
232 B & Fn 52	35c,92c,104c,105c
233 B & Fn 53	50c,92c,94a,109c, 110c
234 B	67b,70c
Fn 10 for 234 B	67b
235 B & Fn 7	94a,109c,110c
236 B & Fn 51	100c,113c
237 B	113c
238 B & Fn 54	15c,113c
239 B	50c,94a
240 B	35c,118c
241 B	82c
242-247 B	13c,120c
248 B	15c
249-253 B	13c
254 B	50c,94a
255 B	94a
256 B	47c
257 B	92bc,94a,95b
Fn 1 for 257 B	92b,95b
258,259 B	15c
260 B	55ac
Fn 10 for 260 B	55a
261 B & Fn 10,20	53a,55c
262 B	55c,137c
263,264 B & Fn 1,39	92c,94a
265 B	118c
266 B & Fn 55	37c,38c,55c,75c
267 B	30bc
268 B & Fn 56	50c,55a,94a
269 B & Fn 17	55ac
270 B	30c
271 B	25c
272 B	35c,94a
273 B	55a,94a,137c
274 B	94a
275 B	50c,94a
276 B	3ac,92c,94a
277 B & Fn 57	82c,94a
278 B	65c,85a
279 B	78bc,79b,94a
Fn 39 for 279 B	78b,79b
280 B	95ab
281 B & Fn 10	53a
282 B	30bc
283,284 B	94a,109c,110c
285,286 B	50c,94a
Fn 51 for 285 B	50c
287,288 B	94a,118bc
Fn 5 for 287 B	118bc
289 B	21b,22b,34b,118b, 46c,102c
Fn 58	21b,22b,34b,118b
290 B	46c,102c
291 B	93c
292 B	102c
293 B	14c,102c
294 B & Fn 51	93c
295 B	93c
296 B	14c
297 B	15c
298 B	13c
299 B	15c
300 B	102c
301 B	3c,13c
302 B	13c,15c
303 B	50c
304 B & Fn 60	27b,45bc,30bc,94a
305 B	126c,127a
306 B & Fn 61	27b,45bc,59b,67bc, 69b,70c,80b,94a
Fn 9 for 306 B	27b,45b,59b,63b, 69b,80b
Fn 22 for 306 B	27b,45bc,59b,67bc, 69b,70c,80b
307 B	101ac
308 B	16c
309 B & Fn 17	99a
310 B & Fn 27	3a
311 B & Fn 62	3a,137c
312 B	3a,16c
313 B & Fn 63	16c,74c,82c
314 B	3a
315 B	3ac
316 B	59b
317 B	50bc
318 B	94a,116b,117c
Fn 1 for 318 B	94a,116b
Fn 10 for 318 B	116b,117c
319 B & Fn 64	8b,42b,94a,116b, 117c,118b
Fn 5 for 319 B	8b,42b,115b,117c, 118b
320 B & Fn 65	55ac,84b,94a,116b, 117c
321 B	136c
322 B	27c,94a
Fn 10 for 322 B	94a
323 B	94a
324 B	132c
325-327 B	11c,94a
328 B & Fn 66	12c,48c,92c,94a, 109c,110c
329 B	13c
330-332 B	15c,102c
333,334 B	13c,102c
335,336 B	13c
337,338 B	15c

(Continued on the next page)

25. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS) REQUIREMENTS: FUNGI (Concluded)

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26. ESSENTIAL ORGANIC COMPOUNDS (VITAMINS AND OTHER) REQUIREMENTS: BACTERIA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 5 for 11 I	6b	3,8,10,11,14-17 EE		16 QQ, 1-17 RR,	
1-17 B	1a,2a	FFGG,Fns 10,11,15	20a,21a,22a,23a,24a	Fn 1	36a
3,11,16 C E-R	3b	3,11,12 HH, Fns 1,		1-17 SS	35a
3,11,16 D	4b,5b	10	25a,26a	1-17 TT	36a
1-17 S-U	7a,8a,9a	17 II, Fn 20	27a	1-17 UU	1a,37a
1-17 V-X, Fn 1	10a	1-17 JJ	26a	1-17 VV	38a
1-17 Y	1a,11a,12a	16,17 KK, Fns 16,21	26a,28a,29a	11,12 WW, Fns 1,14	38a,39a,40a.
1-17 Z, Fn 7	13a,14a	11,12 LL	30a	11,12 XX, Fns 1,14	38a
17 HH, Fn 17	13a	11 MM	31a,32a,33a	3,11,12,14,16 YYZZ,	
3,5,8,11-17 CCDD,		11 NN, Fn 13	34a	Fns 8,15	41a,42a
Fns 1,9,10,18	15a,16a,17a,18a,19a	1-17 OOPP	35a		

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27. DAILY NUTRIENT ALLOWANCES: MAN, ADULT, CANADA

Reference: Values calculated and adapted from Bull. on Nutrition, Canadian Council on Nutrition, Ottawa: King's Printer and Controller of Stationery, 1950.

Reviewers: Crampton, E. W.; Dobson, L. G.; Hiltz, M.; McHenry, E. W.; Pett, L. B.; Sylvestre, J. E.; Young, E. G.

28. DAILY NUTRIENT ALLOWANCES: MAN, CHILDHOOD, CANADA

Reference: Values calculated and adapted from Bull. on Nutrition, Canadian Council on Nutrition, Ottawa: King's Printer and Controller of Stationery, 1950.

Reviewers: Crampton, E. W.; Dobson, L. G.; Hiltz, M.; McHenry, E. W.; Pett, L. B.; Sylvestre, J. E.; Young, E. G.

29. DAILY NUTRIENT ALLOWANCES: MAN, ADULT, UNITED KINGDOM

References: Values calculated and adapted from Report of the Committee on Nutrition, London: British Medical Association, 1950, and Report of the National Food Survey Committee, London: Her Majesty's Stationery Office, 1952.

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30. DAILY NUTRIENT ALLOWANCES: MAN, INFANCY AND CHILDHOOD, UNITED KINGDOM

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31. DAILY NUTRIENT ALLOWANCES: MAN, ADULT, U.S.A.

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
32,33,36,39,40 B-I 28,30,34 B-I	1 Calc. and adapted from 2	All other values	Calc. and adapted from 3	Fn 2,3,5-8,10,12-14, 16-19,21,24,26,28, 30-33,35-37 Fn 4,9	3 4

References: (1) West, E. S., and Todd, W. R., Textbook of biochemistry, New York: The MacMillan Co., 1951. (2) Report of the Food and Nutrition Board, National Research Council, 1948. (3) Forthcoming revision of certain values in ref. 2,to be issued by the Food and Nutrition Board, National Research Council. (4) Maynard, L. A., J. Nutrition 28:443, 1944.

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32. DAILY NUTRIENT ALLOWANCES: MAN, INFANCY AND CHILDHOOD, U.S.A.

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
32,33,36,39,40 B-M 28,30,35 B-M	1 Calc. and/or adapted from 2	All other values	Calc. and/or adapted from 3	Fn 1 Fn 2-4,7,8,10-12, 14,17,19-25,27-29 Fn 5,6	3,5 3 4

References: (1) West, E. S., and Todd, W. R., Textbook of biochemistry, New York: The MacMillan Co., 1951. (2) Report of the Food and Nutrition Board, National Research Council, 1948. (3) Forthcoming revision of certain values in ref. 2, to be issued by the Food and Nutrition Board, National Research Council. (4) Maynard, L. A., J. Nutrition 28:443, 1944. (5) This book, p111.

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33. DAILY NUTRIENT ALLOWANCES: CAT

Reference: Table contributed by Albanese, A. A., and Albanese, J. O., and adapted from Robinson, H. E., in Appraisal of human dietaries by animal experiment, edited by Williams, R. R., New York, 1947.

Reviewers: Albanese, A.A.; Hockett, R. C.; Morris, M. L.; Newlin, H. E.

34. DAILY NUTRIENT ALLOWANCES: BEEF CATTLE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 D-G & Fn 4,5 12 B 13 B 15 B-G & Fn 15	7 2c 3c 8c	Fn 11 Fn 20 Fn 25,28	9d 4c b	Fn 27 All other values	5c 1 checked or revised by a

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References: (1) Calculated from and in agreement with values in a forthcoming Report of the Committee on Animal Nutrition, National Research Council. (2) Johnson, B. C., et al., J. Nutrition 43:37, 1951. (3) Draper, H. H., et al., J. Animal Sci. 11:332, 1952. (4) Draper, H. H., and Johnson, B. C., J. Nutrition 46:37, 1952. (5) Bentley, O. G., and Phillips, P. H., J. Dairy Sci. 34:396, 1951. (6) Forbes, E. B., and Kriss, M., Proc. Am. Soc. Animal Production, 1931. (7) Morrison, F. B., Feeds and feeding, Ithaca, N. Y.: Morrison Co., 1948. (8) Blaxter, K. L., Watts, P. S., and Wood, W. A., Brit. J. Nutrition 6:125, 1952. (9) Rusoff, L. L., and Hag, M. O., J. Animal Sci. 10:334, 1951.

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35. DAILY NUTRIENT ALLOWANCES: DAIRY CATTLE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-G	s	15 B-G	7b,8b,9b,9d,e	33 B-G	12b
2,5,9 B-G	1,e	16 B	d	Fn 1-3,12,17,24-26	1
3 B-E G	1e	18 B	1	Fn 4,9	a
3 F	d	19 B	10b,c,10d,10e	Fn 10	1
11 B	1,e	20,22,24 B	1,e	Fn 11	2d,3d
12 B	5b,5e	23 B	11b	Fn 14,16	4c
13 B	6b,c,d	25-28,30,31,32,34,		Fn 27	c
14 B-G	1,e	35,37,38 B-G	1,e		

Contributors: (a) Hibbs, J. W. (b) Mitchell, H. H. (c) Rusoff, L. L. (d) Swanson, E. W. (e) Thomas, J. W.

References: (1) Values were calculsted and adapted from data in a Report of the Committee on Animal Nutrition, National Research Council, April, 1950. Copy of report was contributed by Voris, A. L. (2) Tyznik, W., and Allen, N. N., J. Dairy Sci. 34:493, 1951. (3) Stoddard, G. E., et al., J. Animal Sci. 8:630, 1949. (4) Rusoff, L. L., and Hag, M. O., J. Animal Sci. 10:331, 1951. (5) Johnson, B. C., et al., J. Nutrition 43:37, 1951. (6) Draper, H. H., et al., J. Animal Sci. 11:332, 1952. (7) Blaxter, K. L., Watts, P. S., and Wood, W. A., Brit. J. Nutrition 6:125, 1952. (8) Gullickson, T. W., and Calverly, C. E., Science 104:312, 1946. (9) Gullickson, T. W., J. Dairy Sci. 32:495, 1949. (10) Johnson, B. C., et al., J. Biol. Chem. 167:729, 1947. (11) Draper, H. H., and Johnson, B. C., J. Nutrition 46:37, 1952. (12) Bentley, O. G., and Phillips, P. H., J. Dairy Sci. 34:396, 1951. (13) Forbes, E. B., and Kriss, M., Proc. Am. Soc. Animal Prod., p113, 1931.

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36. DAILY NUTRIENT ALLOWANCES: DOG

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
2 B	1d,2d	14 BC	19c	25 BC	19c
Fn 2	1d	Fn 10	10d,11d	Fn 15	1d,2d
2 C	1d,3d	15 B	19c	Fn 16	7d
3 B	1d	16 B & Fn 11	1d	26 B	19c
3 C	19c	16 C	a	Fn 17	1d,2d
Fn 3	1d	17 C	d	26 C	2d
5 BC	1d	18 C & Fn 12	12d	27 BC	19c
Fn 4	d	19 B	1d,13d,19c	28 BC	19c
6,7 B	s	19 C	19a	29 C & Fn 18	18
6,7 C	19c	20 B	14d,19c	30-35 BC	19c
9 BC	19c	20 C	19c	Fn 19,21	1d,2d
11 C & Fn 6	d	21 BC	d	Fo 20	7d
Fn 7	b	22 BC	19c	37 B	1d,2d
12 B	6d,7d,8d,9d,19c	23 B	15d,19c	37 C	2d
12 C	19c	23 C	16d	38 C	18d
13 B	6d,7d,8d	24 B	1d,17d,19c	39 BC	19c
13 C	19c	24 C	17d,19c		

Contributors: (a) Allison, J. B. (b) Cunha, T. J. (c) Robinson, H. E. (d) Schaefer, A. E.

References: (1) Schaefer, A. E., in Frear, Agricultural Chemistry, II, Chap. XIX, Boston: D. Van Nostrand Co., 1951. (2) Arnold, A., and Elvehjem, C. A., J. Am. Vet. Med. Assn. 91:515, 1937. (3) Ibid. 95:187, 1939. (4) Linton, R. G., Vet. Med. 32:86, 1937. (5) Crimm, P. D., and Short, A. M., Am. J. Physiol. 118:477, 1937. (6) Schaefer, A. E., Copeland, D. H., and Salmon, W. D., J. Nutrition, 43:201, 1951. (7) Schaefer, A. E., Veterinary Symposium, Gaines Dog Research Center, 1951. (8) Burns, M. M., and McKibbin, J. M., J. Nutrition, 44:487, 1951. (9) Schaefer, A. E., McKibbin, J. M., and Elvehjem, C. A., Proc. Soc. Exp. Biol. Med. 47:365, 1941. (10) Anderson, H. D., Elvehjem, C. A., and Gonce, J. E., Jr., Proc. Soc. Exp. Biol. Med. 42:750, 1939. (11) Anderson, H. D., Elvehjem, C. A., and Gonce, J. E., Jr., J. Nutrition, 20:433, 1940. (12) Thaddea, S., Z. Physiol. Chem. 279:94, 1943. (13) Schaefer, A. E., McKibbin, J. M., and Elvehjem, C. A., J. Biol. Chem. 144:679, 1942. (14) Ibid., 143:321, 1942. (15) Potter, R. L., Axelrod, A. E., and Elvehjem, C. A., J. Nutrition, 24:449, 1942. (16) Spector, H., Maass, A. R., Michaud, L., Elvehjem, C. A., and Hart, E. B., J. Biol. Chem. 150:75, 1943. (17) Maass, A. R., Michaud, L., Spector, H., Elvehjem, C. A., and Hart, E. B., Arch. Biochem. 4:105, 1944. (18) Wesson, L. G., Science 75:339, 1932. (23) Calculated from values in a forthcoming Report of the Committee on Animal Nutrition, National Research Council.

Reviewers: Allison, J. B.; Cravens, W. W.; Cunha, T. J.; Earle, I. P.; Norris, L. C.; Robinson, A. D.; Schaefer, A. E.; Taylor, M. W.; Wesson, L. G.

37. DAILY NUTRIENT ALLOWANCES: FOX AND MINK

Data Coordinates and Footnotes	Contributors and References
2 FG NO	Calc. fr 1a
6,14,26,37 B-Q	1a
All other values	Calc. fr 1 by b

Contributors: (a) Harris, L. E. (b) Miller, D. F.

Reference: (1) Forthcoming Report of the Committee on Animal Nutrition, National Research Council.

Reviewers: Cabell, C. A.; Harris, L. E.; Miller, D. F.; Norris, L. C.; Schaefer, H. C.; Smith, S. E.

38. DAILY NUTRIENT ALLOWANCES: HORSE

Contributor: (a) Pearson, P. B.

Reference: (1) Values in this table calculated and adapted from a forthcoming Report of the Committee on Animal Nutrition, National Research Council, by Pearson, P. B., Winchester, C. F., and Harvey, A. L.

Reviewers: Cuppa, P. T.; Lawton, A. H.; Mitchell, H. H.; Norris, L. C.; Pearson, P. B.; Schneider, B. H.; Winchester, C. F.

39. DAILY NUTRIENT ALLOWANCES: MONKEY

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
2 B	1c	15 B	15c	23 B	8b,8c
2-39 C	b	16 B	3c,4b,4c,5c	24 B	9b,9c,10c
9 B	2b	16 C	16a	25 B	14b
10 B	2c,11b	19 B	6b	Fn 5	c
11 B	12b	20,22 B	7b	Fn 14	c
14 B	13b				

Contributors: (a) Rinehart, J. F., and Greenberg, L. D. (b) Shaw, J. H., (c) Smith, S. C.

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Reviewers: Greenberg, L. D.; McCall, K. S.; Rinehart, J. F.; Shaw, J. H.; Smith, S. C.; van Wagenen, G.; Waisman, H. A.

40. DAILY NUTRIENT ALLOWANCES: RAT

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-F	b	14 EF	b	21 EF	b
2 BCD	Calc. fr 11	15 B	a	22,23 B E	e
3 BCD	a	15 CD	1a	22,23 C	6c
4 B-F	b	15 EF	e	22-24 D	1a
5 B DEF	b	16 BCD	1a	22 F	8a
5 C	5c	16 EF	b	23 F	9a
6,7 B-F & Fn 1	b	Fn 6	3a,4a	24 B	e
8 B-F	10	17 B-F	b	24 C	7c
9-11 BCD	1a	Fn 7	2de,8de	24 EF	10
9-11 EF	b	18,19 BCD	1a	25,26 B F	Calc. fr 10
12 B	a	18,19 EF	b	27 B F & Fn 11	b
12 CD	1a	20 BC	a	28-38 BCDEF	Calc. fr 10
12 E	e	20 D	1a	39 BC	Calc. fr 10
12 F	10	20 EF	e	39 DEF	b
13 B-F & Fn 4	b	21 BCD	1a	Fn 12	b
14 BCD	1a	21 EF	b		

(Continued on the next page)

40. DAILY NUTRIENT ALLOWANCES: RAT (Concluded)

Contributors: (a) Brown, R. A. (b) Daft, F. S. (c) Mills, C. A. (d) Pavcek, P. L. (e) Slanetz, C. A.

References: (1) Brown, R. A., and Sturtevant, M., Vitamins and hormones 7:171, 1949. (2) Pavcek, P. L., and Baum, H. M., Am. Chem. Soc. Meeting Div. Biol. Chem., Abst. 2p, April, 1941. (3) Endicott, K. M., Daft, F. S., and Ott, M., Arch. Path. 40:364, 1945. (4) Kornberg, A., Daft, F. S., and Sebrell, W. H., Arch. Biochem. 8:431, 1945. (5) Mills, C. S., Arch. Biochem. 3:333, 1944. (6) Ibid., 2:159, 1943. (7) Mills, C. A., Am. J. Physiol. 133:525, 1941. (8) Slanetz, C. A., Am. J. Vet. Res. 4:182, 1943. (9) Sure, B., J. Nutrition 19:57, 1940. (10) Farris, E. J., and Griffith, J. Q., The rat in laboratory investigation, Philadelphia: J. B. Lippincott Co., 1949. (11) Brody, S., Bioenergetics and growth, New York: Reinhold Publ. Corp., 1945.

Reviewers: Bosshardt, D. K.; Brown, R. A.; Daft, F. S.; Fenton, P. F.; Mills, C. A.; Pavcek, P. L.; Schweigert, B. S.; Slanetz, C. A.

41. DAILY NUTRIENT ALLOWANCES: GERM-FREE RAT, CHICKEN

References: Data contributed by Reyniers, J. A., and Luckey, T. D., and adapted from Reyniers, J. A., et al., Lobund Report 2, Notre Dame, Indiana: University of Notre Dame, 1950, and Lobund Report 3 (in press).

Reviewers: Bird, H. R.; Briggs, G. M.; Combs, G. F.; Heuser, G. F.; Luckey, T. D.; Mills, C. A.; Slanetz, C. A.

42. DAILY NUTRIENT ALLOWANCES: CERTAIN RODENTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BCD	1a	6 D	31c	13 D	26b
2 B	Calc. fr 5,6,7 B	7 D	3c	14 B	8f
2 C	Calc. fr 5,6,7 C	8 D	4c	14-18 C	7f
2 D	Calc. fr 5,6,7 D	9,11,12,14-24 D	Calc. fr c	19 C	8f
3 B	Calc. fr 5,6,7,34 B	10 BC	d	25-36,38,40 D	Calc. fr c
3 C	Calc. fr 5,6,7,34 C	11,12,16,17,19-24, 41 B		34 B	30f
3 D	ce		24f	Fn 2-10,15,16,18,21	f
4-7,9,34 C	7f	11,12,20-24,41 C	25f	Fn 11,12	c
5,6,7,9 B	8f	13 C	d	Fn 14	26b
5 D	Calc. fr c				

Contributors: (a) Bing, F. C. (b) Bosshardt, D. K. (c) Fenton, P. F. (d) Johnson, B. C. (e) Morris, H. P. (f) Schweigert, B. S.

References: (1) Bing, F. C. and Mendel, L. B., Am. J. Physiol. 98:169, 1931. (2) Fenton, P. F. and Carr, C. J., J. Nutrition 43:441, 1951. (3) Fenton, P. F. and Carr, C. J., J. Nutrition 45:225, 1951. (4) White, E. A., Foy, J. R., and Cerecedo, L. R., Proc. Soc. Exp. Biol. Med. 54:301, 1943. (5) Beard, H. H., Am. J. Physiol. 75:668, 1925. (6) Sure, B., J. Nutrition 19:57, 1940. (7) Hamilton, J. W., and Hogan, A. G., J. Nutrition 27:213, 1944. (8) Schweigert, B. S., Vitamins and Hormones 6:55, 1948. (9) Beard, H. H. and Pomerene, E., Am. J. Physiol. 89:54, 1929. (10) Pomerene, E. and Beard, H. H., Am. J. Physiol. 92:282, 1930. (11) Wolfe, J. M. and Salter, H. P., J. Nutrition 4:185, 1931. (12) Murphy, R., Science 89:203, 1939. (13) Bryan, W. L. and Mason, K. E., Am. J. Physiol. 131:263, 1940. (14) Morris, H. P. and Lippincott, S. W., J. Nat. Cancer Inst. 2:29, 1941. (15) Goettsch, M., J. Nutrition 23:513, 1942. (16) Cerecedo, L. R., and Vinson, L. J., Fed. Proc. 3:55, 1944. (17) Nielsen, E. and Black, A., J. Nutrition 28:203, 1944. (18) Morris, H. P., and Dubnik, C. A., J. Nat. Cancer Inst. 8:127, 1947. (19) Fenton, P. F. and Cowgill, G. R., J. Nutrition 34:273, 1947. (20) Fenton, P. F., Shrader, R. E., and Cowgill, G. R., Fed. Proc. 8:382, 1949. (21) Fenton, P. F., Cowgill, G. R., Stone, M. A., and Justice, D. H., J. Nutrition 42:257, 1950. (22) Bing, F. C., Adams, W. K., and Bowman, R. O., J. Nutrition 5:571, 1932. (23) Bosshardt, D. K., Ydse, L. C., Ayres, M. M., and Barnes, R. R., J. Nutrition 31:23, 1946. (24) McIntire, J. W., et al., J. Nutrition 27:1, 1944. (25) Granados, H., and Dam, H., Fed. Proc. 9:360, 1950. (26) Bosshardt, D. K., Paul, W. J. and Barnes, R. H., J. Nutrition 40:595, 1950. (27) Leroy, J., Compt. rend. Soc. Biol. 94:431, 1926. (28) Kemmerer, A. R., Elvehjem, C. A. and Hart, E. B., J. Biol. Chem. 92:623, 1931. (29) Day, H. G. and Skidmore, B. E., J. Nutrition 33:27, 1947. (30) Hegsted, D. M., et al., J. Biol. Chem. 138:459, 1941. (31) Fenton, P. F. and Cowgill, G. R., J. Nutrition 33:703, 1947.

Reviewers: Bing, F. C.; Bosshardt, D. K.; Brown, R. A.; Cerecedo, L. R.; Cunha, T. J.; Fenton, P. F.; Johnson, B. C.; Masoo, K. E.; Mills, C. A.; Morris, H. P.; Pavcek, P. L.; Schweigert, B. S.

43. DAILY NUTRIENT ALLOWANCES: SHEEP

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-G	2a	15 D-G	b	34 C	a
2-4 C	a	25 C	a	37 B	1b
6,7 B-G	a	26 B	1b	Fn 14	h
10 C	c	27,28 BC	b	All other values	1
13 D-F	a				

Contributors: (a) Beeson, W. M. (b) Ellis, N. R. (c) Kammlade, W. G., Jr.

References: (1) Calculated from and in agreement with data in a forthcoming Report of the Committee on Animal Nutrition, National Research Council. (2) Morrison, F. B., Feeds and feeding, Ithaca, N. Y.: Morrison Co., 1948.

Reviewers: Beeson, W. M.; Ellis, N. R.; Johnson, B. C.; Kammlade, W. G.; Norris, L. C.

44. DAILY NUTRIENT ALLOWANCES: SWINE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
2,3,5,7,9,10 B-E	1a	13,14 B-E & Fn 10	1a	Fn 17	2d
Fn 5	f	15 B-E & Fn 13	3d	22 B	e
Fn 6	d	16 B	c	23-26,28,30-35,37,	
Fn 7	b	Fn 15	1	39 BCDE	1a
12 B & Fn 8	1a,4d	19,20 B-E	1a	Fn 20	1

Contributors: (a) Beeson, W. M. (b) Cunha, T. J. (c) Johnson, B. C. (d) Mitchell, H. B. (e) Taylor, M. W. (f) Zeller, J. H.

References: (1) Calculated from and in agreement with values in a forthcoming Report of the Committee on Animal Nutrition, National Research Council. (2) Luecke, R. W., et al., J. Nutrition 36:417, 1948. (3) Adamstone, F. B., et al., Ann. N. Y. Acad. Sci. 52:260, 1949. (4) Nesheim, R. O., and Johnson, B. C., J. Nutrition 41:149, 1950.

Reviewers: Beeson, W. M.; Cunha, T. J.; Ellis, N. R.; Johnson, B. C.; Luecke, R. W.; Mitchell, H. H.; Norris, L. C.; Schneider, B. H.; Taylor, M. W.; Zeller, J. H.

45. DAILY NUTRIENT ALLOWANCES: CHICKEN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B D-K	2f	16 B	1a,1c	26 D I	f
1 C	2e	16 C H	f	28 B G	1a
2 B DEF	2e	16 E	d	28 C H	2f
3 BC	1acf	16 G	1a,7b	30 BC EF	1a,1c
3 D-K	1a	18 B	1c	30 GH JK	1a
4 B EFG IJ	2e	18 C H	2f	31 BC GH	2f
5 BC	1acf	18 G	1a	32 B	1a,1c
5 DEF IJK	1a	19 B	1a,1c,1f	32 C H	2f
5 GH	1f	19 C H	2f	32 G	1a
6 B E-J	2e	19 G	1a	33 B	1c
7 B-K	2f	20 B-F	1a,1c	33 EFG K	1a
9 B-K	1acfg	20 G JK	1a	34 B-F	1c
11 B	1acf	20 H	1a,2f	34 G-K	1a
11 C E H J	2f	22 B D-G JK	1a,1c	35 BC	1c
11 FG K	1a	22 C H	2f	35 GH	1a
12 B G	1a	23 B-F	1a,1c	37 B-F	1c
12 C EF H JK	2f	23 G-K	1a	37 G-K	1a
13 B G	3c,6c	24 BC GH	2f	Fn 1,2,3	2f
13 F	6c	25 BCD	1c,1f	Fn 5,8	f
13 K	5c	25 E-K	1a	Fn 7,11	b
14 B-K	1a,1c	26 BC E-H JK	g	Fn 12,14	d
15 BC GH	2f				

Contributors: (a) Bird, H. R. (b) Briggs, G. M. (c) Combs, G. F. (d) Johnson, B. C. (e) McKee, R. W. (f) Nestler, R. B. (g) Scott, M. L.

References: (1) Calculated from and in agreement with data in a forthcoming Report of the Committee on Animal Nutrition, National Research Council. (2) Poultry Nutrition, South Pasadena, California: Ewing Publishing Co., 1951. (3) Davis, R. L., and Briggs, G. M., Poultry Sci. 30:628, 1951. (4) Milligan, J. L., Arscott, G. H., and Combs, G. F., Poultry Sci., 31: 830, 1952. (5) Ibid., 31:595, 1952. (6) Norris, L. C., Reuser, G. F., and Miller, R. F., Cornell Feed Service, November 1950, p10. (7) Titus, H. W., The scientific feeding of chickens, Danville, Ill.: Interstate, Inc., 1949.

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46. DAILY NUTRIENT ALLOWANCES: TURKEY

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
3,5,9,12,14,25,33,		16 B	1a	25,34 CD	1e
34 B	1a,1e	16 D	3b	26 BCD	e
3 C	1a	18 B	4d	Fn 10	c,e
3 D	1a,2d	19,22 B	3b	Fn 11	e
5,9 CD	1a	20 B	1a	30,35 BCD	4d
7 BCD	4d	20 CD	4d	33 D	1a
9 CD	1a	23 B D	1a,4d	34 CD	1e
14 BCD	1a,1e	23 C	4d	37 BCD	1a

Contributors: (a) Bird, H. R. (b) Johnson, B. C. (c) Kratzer, F. R. (d) Nestler, R. B. (e) Scott, M. L.

References: (1) Calculated from and in agreement with values in a forthcoming Report of the Committee on Animal Nutrition, National Research Council. (2) Wilson, D., et al., Poultry Sci. 23:314, 1944. (3) Adapted from Johnson, B. C. (unpublished). (4) Marsden, S. J., and Martin, R., Turkey management, Danville, Ill.: Interstate, 1949.

Reviewers: Bird, H. R.;Groschke, A. C.; Hogan, A. G.; Johnson, B.C.; Kratzer, F. R.; Lawton, A. B.; Nestler, R. B.; Norris, L. C.; Russell, W. C.; Scott, M. L.; Slinger, S. J.; Wilcke, H. L.

47. DAILY NUTRIENT ALLOWANCES: FISH

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
5 B-E	11a	13 BC E	2e	19 D C	2a
5 F HI	12a	14 BCD F-I	2e	19 F HI	6a
8 B-I	2a	14 E	1a	20 E	13b
9 BCD F-I	2a	15 BC	4a	21 BC E	7a
9 E	13b	15 D F	2a	21 D F I	2a,14a
Fn 4	Calc. fr 13 by b	15 E	1a,4a	22 BC E	7a
10 BC E	3a	16 BC	1a	22 D F HI	2a,14a
10 D F-I	2a,9a	16 D F	2a	23 BC E	8a
11 BCD F-I	2a,14a	16 E	13b	23 D F H	9a
11 E	13b	18 BC E	3a	23 C	2a
12 B-I	2a	18 F	2a,14a	23 I	10a
		19 BC E	7a	29 B-E	15b

Contributors: (a) Halver, J. E. (b) Phillips, A. M., Jr.

References: (1) Wolf, L. E., Prog. Fish Cult. 13:21, 1951. (2) Halver, J. E., unpublished research report, Dept. of Int., Fish and Wildlife Service, 1950-51. (3) Phillips, A. M., Jr., Fish. Res. Bull., Albany: N. Y. Conserv. Dept. 10:9, 1947. (4) Ibid., 12:5,1949. (5) Ibid., 8:7, 1945. (6) Rucker, R. R., Johnson, H. E., and Kaydas, C. M., Prog. Fish. Cult. 14:10, 1952. (7) Phillips, A. M., Jr., et al., Fish. Res. Bull., Albany: N. Y. Conserv. Dept. 6:11, 1944. (8) Ibid., 9:11, 1946. (9) Donaldson, L. R., School of Fisheries, Univ. of Washington, Seattle, (unpublished). (10) Burrows, R. E., and Karrick, N. L., Ind. Res. and Dev. Div. Report No.1, 1947. (11) Phillips, A. M., Jr., et al., Fish Res. Bull. Albany: N. Y. Conserv. Dept. 11:7, 1948. (12) Phillips, A. M., Jr., U. S. Fish and Wildlife Service, Cortland, N. Y., 1951, (unpublished). (13) McLaren, B. A., Keller, E., O'Donnell, J., and Elvehjem, C. A., Arch. Biochem. 15:169, 1947. (14) Halver, J. E., unpublished research report, Dept. of Int., Fish and Wildlife Service, 1951-1952. (15) Mavine, D., J. Exp. Med. 19:70, 1914.

Reviewers: Halver, J. E.; McLaren, B. A.; Phillips, A. M., Jr.; Rucker, R. R.; Wolf, L. E.

48. DIETS, LOW COST: MAN, U.S.A.

Data Coordinates and Footnotes	Contributors and References
1-19 B	1a
All others & Fn 1, 2,3,11	2b

Contributors: (a) Krogman, W. M. (b) Phipard, E. F.

References: (1) Values calculated and adapted from Krogman, W. M., Growth of man, Tabulae biologicae, Den Haag, Netherlands: Uitgererij, Dr. W. Junk, 20, 1941. (2) Values calculated and adapted from U. S. Dept. of Agriculture, Miscellaneous Publication, No. 662, U. S. Dept. Agr., 1950.

Reviewers: Krogman, W. M.; Phipard, E. F.; Porter, T.

49. DIETS, MODERATE COST: MAN, U.S.A.

Data Coordinates and Footnotes	Contributors and References
1-19 B	1a
All others & Fn 1, 2,3,11	2b

Contributors: (a) Krogman, W. M. (b) Phipard, E. F.

References: (1) Values calculated and adapted from Krogman, W. M., Growth of man, Tabulae biologicae, Den Haag, Netherlands: Uitgererij, Dr. W. Junk, 20, 1941. (2) Values calculated and adapted from U. S. Dept. Agriculture, Miscellaneous Publication, No. 662, U. S. Dept. Agr., 1950.

Reviewers: (a) Krogman, W. M. (b) Phipard, E. F. (c) Porter, T.

50. DIETS: LABORATORY AND DOMESTIC ANIMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-15 CDE	6	83,84,86-112 BCDE & Fn 3,4	11h	141,142 BCDE	e
16-27 CDE	5	113-118 CDE	8	143-150 BCDE	2d
28-41 BCDE	b,9f	119-132 CDE	g	151-164 CDE	7
42-62 BCDE	1a	133 C	e	165-176 CDE	4
63-82 CDE	c	133-140 DE	b	177-209 BCDE	1a

Contributors: (a) Bird, H. R. (b) Luckey, T. D. (c) Miller, H., and Burgess, H. M. (d) Moment, G. B. (e) Poiley, S. M. (f) Reyniers, J. A. (g) Shaw, J. H. (h) Tunison, A. V.

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51. ZOO DIETS: MAMMALS, CARNIVORES

References: These data compiled and calculated from data contributed by (a) Crosbie, G. G.; (San Diego Zoological Gardens); (b) Goss, L. J., Gandall, C. P., and McClung, R. M., (New York Zoological Park); (c) Luckey, T. D., (Lincoln Park Zoo, Chicago, Ill., M. Perkins, Director).

Reviewers: Benchley, B. J.; Conway, W. G.; Crosbie, G. G.; Gandal, C. P.; Goss, L. J.; Luckey, T. D.; McClung, R. M.; Mann, W. M.; Ratcliffe, H. L.; Vierheller, G. P.; Walker, E. P.

52. ZOO DIETS: MAMMALS, HERBIVORES

References: These data compiled and calculated from data contributed by (a) Crosbie, G. G. (San Diego Zoological Gardens); (b) Goss, L. J., Gandal, C. P., and McClung, R. M., (New York Zoolngical Park); (c) Luckey, T. D. (Lincoln Park Zoo, Chicago, Ill., M. Perkins, Director).

Reviewers: Benchley, B. J.; Conway, W. G.; Crosbie, G. G.; Gandal, C. P.; Goss, L. J.; Luckey, T. D.; McClung, R. M.; Mann, W. M.; Ratcliffe, H. L.; Vierheller, G. P.; Walker, E. P.

53. ZOO DIETS: BIRDS

References: These data compiled and calculated from data contributed by (a) Goss, L. J., Gandall, C. P., and McClung, R. M. (New York Zoological Park), and (b) Crosbie, G. G.

Reviewers: Benchley, B. J.; Conway, W. G.; Crosbie, G. G.; Gandal, C. P.; Goss, L. J.; Luckey, T. D.; McClung, R. M.; Mann, W. M.; Ratcliffe, H. L.; Vierheller, G. P.; Walker, E. P.

54. REPRESENTATIVE SYNTHETIC DIETS: INSECTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-44 B	1b	1-44 G	10b,11a	Fn 10,11,12,13	c
1-44 C	2c	1-44 H	12c	Fn 15	14b
1-44 D	3c,4a	Fn 2,3,4	b	Fn 16	15b,c
Fn 1	5a,6a,7a,13a,b	Fn 6	c	Fn 17	16b,c
1-44 E	8b	Fn 7	b	Fn 18	17b
1-44 F	9b	Fn 8	c		

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55. SELECTED SOURCES FOR CERTAIN NUTRIENTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
34,36-39 B	2b	50-54 B	5b	77 B	8b,9b,10b
35 B	2b,3b	55-62 B	6b	80-85 B	8b
40-42 B	b	63-67 B	7b	All other values and Fn 3,6	1a
43-49 B	4b	74-76,78,79 B	8b,9b		

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56. BALANCED SALT SOLUTIONS FOR ISOLATED ANIMAL TISSUES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,6,9,10,13 B & Fn 8	1d	1,4,6,9,10,12, 13 GH & Fn 2,3,6	6d	2,3,5,6,7,9,10,11, 13 L & Fn 4,6,7	10de
1,4,6,10 C	2d	1,4,5,6,7,9,10,11, 13 I	7bd	1,4,5,6,7,9,10,11, 13 M	11bd
1,6,9,10 D & Fn 1	3d	1,4,6,7,9,10,11, 13 J	8bd	2,4,6,7,9,10,11, 13 R	12d
1,4,6,9,10,12,13 E & Fn 6	4d	1,5,6,9,10,12,13 K	9abcd	1,4,6,9,10,11,13 O	13bd
1,4,6,10,12,13 F	5cd				

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Reviewers: Commoner, B.; Fischer, A.; Hanks, J. H.; Morgan, J. F.; Parker, R. C.; White, P. R.

57. NUTRIENT SOLUTIONS: HIGHER PLANTS

Data Coordinates and Footnotes	Contributors and References
1-6,8,9,11,13 B	2b
1-5,7,8,10,12,13 C	3e
Fn 1	1g,4d,5f,6i,7a,8a, 9h,10c
Fn 2	b
Fn 3	g

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58. CULTURE MEDIA: ISOLATED PLANT TISSUES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1	1b,4b,5b,12b,14b, 17b,18b,[20b-30b],32b,33b,34b	19,26,29,30 D	3a	14-17 I	b
		1,3,6,8-11,14,15, 17,18,26,27,31 E & Fn 7,19	19b	1,8 J	[56a-61a]
Fn 2	38b,39b,41b,42b			6,9-11,14,17,19, 23,24 J & Fn 13	[56b-61b]
Fn 3	[45b-55b],[62b-67b],[69b-75b]	1,8,26 F	34a	1,7-11,19,26 K & Fn 14	76b,77b,78b
1,3,6,8-11,15,17, 18,26,30 B & Fn 4,19	31b	6,9-11,14-17,19, 22-25,29 F & Fn 8,20	34b	1,7-10,12-17,19, 23,24,26,29 L & Fn 15,16	15b,16b
1,3,6,8,9-11,15, 17,18,21,26,31 C & Fn 5,19	[6b-14b]	3,4,5,8,9,10 G	43a,44a	1,26 M	36a
		18,26 G & Fn 9	43b,44b	6,8,9,10,12-17, 19,24,29 M & Fn 11	36b
1,6,8-10,12,13, 28 D & Fn 6	3b	1 H	40a	22,23 M	b
14-17 D	b	6,8-11,19,20,22-24, 26,30 H & Fn 10, 18	40b	Fn 17	2b,35b,36b,37b,79b
		1,8 I	68a		
		6,9-11,19,32 I & Fn 11,12	68b		

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Reviewers: Caplin, S. M.; Commoner, B.; Hildebrandt, A. C.; Miller, C. O.; Morel, G. M.; Robbins, W. J.; Skoog, F.; Tukey, R. B.; White, P. R.

59. CULTURE MEDIA: FUNGI

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
9,10,12,13,17,21 B & Fn 1	4d	2,4,6,10,14,15,21, 24 D	2d	3,7,8,10,14,19,20, 22,24-28 E	b
1,5,7,9,10,11,14, 19,23,26 C & Fn 2	3a	5,7-9,11,16,18, 19 D & Fn 5,7	c	Fn 4	1,5

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Reviewers: Jennison, M. W.; Joslyn, M. A.; Kaufert, F.; Machlis, L.; Nickerson, W. J.; Pelletier, R. L.; Raper, K. B.; Scheffer, T. C.; Steinberg, R. A.; Tatum, E. L.; Wallin, W. B.; Wolf, F. T.

60. CULTURE MEDIA: ALGAE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
4,11,16,21,22 B & Fn 1	3a,4a,5a,6a	1,4,14,16,21,23,24 E & Fn 5	2a	6,15,16,20,25 H & Fn 7	7a,8a,9a
13,16,21,23,26 C & Fn 2	1abc	5,8,12,16,22,24,27 F & Fn 5	2a,12ac	2,3,7,9,10,17-19, 29-31 B-G & Fn 8, 9	13
6,11,16,22,25 D & Fn 4,10	2a	1,4,14,16,22,28 G & Fn 5,6	2a	Fn 3	10a,11a

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61. CULTURE MEDIA: CERTAIN BACTERIA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1	1a	27,29,30,32,33,35, 37,38,41,44-48, 53,55,57,58,60, 62 E	8b	44,47,53,57,58 G	7a
Fn 2	8b			56,60 G	7c
Fn 5	10a			62-64,67 G	7a
3,7,24,25,27-30 32-34,37,38,40, 42,46-49,51,52, 54,55,57,58,60, 61 B	3a	1-4,6,7,9,10, 12-15,17,19-24, 26,27,29,30 F	4a	1,2,4,5,7,9,10, 12-15,17-24,26, 27,29,30,32,33, 35,37,38,41, 44-48,53,55,57, 58,60,62,67 H & Fn 4	9b
		31,36 F	4c		
1,2,4,6,7,9,10, 12-15,17-25, 27-30,32,33, 37-39,41,44,46, 50,53,55,57,58, 62,66,68 C & Fn 7	5a	32,37-39,43-45, 47 F	4a	1-5,7,9,10,12-15, 17-24,27,29,30, 32,33,35,37,38, 41,44-48,50,53, 55,57,58,60,62, 69 I & Fn 9	6b
		41,46,48 F	4c		
		53,55,57,58,60,62, 64,67 F	4a		
		1,4,6,8,11 G	7a		
		2,3,5,9,10,12-15 G	7c		
1,2,4,6,7,9,10, 12-15,17-24,27, 29,30,32,35,37, 38,41,45-48,50, 53,55,57,58,60, 62,63 D	1a	16,18 G	7a	1-4,6,7,9,10, 12-15,17-24,27, 29,30,32-34,37, 38,41,45-48,50, 53,55,59,62,63, 65,67 J	2a
		17,19-21 G	7c		
		22-24 G	7a		
		26 G	7c		
		27,29,30,32-35,37, 38 G	7a		
1,2,3,6,7,9,10, 12-15,17-24 E	8b	36,41,45,46 G	7c		

Contributors: (a) Pavcek, P. L. (b) Schweigert, B. S. (c) Shorb, M. S.

References: (1) Renderson, L. M., and Snell, E. E., J. Biol. Chem. 172:15, 1948. (2) Hoffmann, H. A., and Pavcek, P. L., J. Am. Chem. Soc. 74:344, 1952. (3) Feeney, R. E., Garibaldi, J. A., and Humphreys, E. M., Arch. Biochem. 17:435, 1948. (4) Shorb, M. S., Proc. Soc. Exp. Biol. Med. 79:611, 1952. (5) Herbst, E. J., and Snell, E. E., J. Biol. Chem. 181:47, 1949. (6) Steele, B. F., et al., J. Biol. Chem. 177:533, 1949. (7) Shorb, M. S., Kao, Y. T. K., and Scott, W. M., Symposium on Hematopoesis, 2nd International Congress of Biochem., Paris, 1952. (8) Schweigert, B. S., et al., J. Biol. Chem. 180:1077, 1949. (9) Ibid., 186:229, 1950. (10) Snell, E. E., et al., J. Am. Chem. Soc. 72:5349, 1950.

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62. CHEMICAL ELEMENT COMPOSITION AND NEUTRALIZING ACTION: INORGANIC FERTILIZERS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 8-16,18,19,21-28	1a	1,4,5,11 H	1a,2a	24,25,35,36 HI	1a
1,5,7,8,10,11 D	1a,2a	7,17,18,20,21,23 HI	1a,2a	6,13-15,22,24,25, 33 I & Fn 17	1a
2,3,4,6,9,12,26-34 D	1a	8,10,32 I	1a,2a	All other values	Calc. fr 1a
21,23 F	1a,2a	2,3,9,12,16,26-31, 34 H & Fn 20	1a		

Contributor: (a) McVickar, M. H.

References: (1) Ignatieff, V., (editor), United Nations Food and Agr. Organization, Agricultural studies 9, 1949. (2) McVickar, M. H., Using commercial fertilizers, Danville, Ill.: Interstate Printers and Publishers, 1952.

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63. CHEMICAL ELEMENT COMPOSITION AND NEUTRALIZING ACTION: ORGANIC FERTILIZERS

Data Coordinates and Footnotes	Contributors and References
Fn 8,9	1a
1-5,7-19,22-27, 29 D	1a
6,21 D	1a,2a
1-8,10-22,25,27-30 HI & Fn 10, 11,12	1a
All other values	Calc. from 1a

Contributor: (a) McVickar, M. H.

References: (1) Ignatieff, V., (editor), United Nations Food and Agr. Organization, Agricultural studies 9, 1949. (2) McVickar, M. H., Using commercial fertilizers, Danville, Ill.: Interstate Printers and Publishers, 1952.

Reviewers: Bear, F. E.; Clark, L. J.; Collins, G. H.; Jacob, K. D.; Marshall, H. L.; McVickar, M. H.; Sauchelli, V.; Turrentine, J. W.

64. SOIL pH REQUIREMENTS: PLANTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
20,29,36,57,63,66, 70 B	2b	2,11,16,30,32,46 C	1c,a	Fn 1	3
16,40,59,65,78,84, 86,90 B & Fn 4,5	1c,2b	8,9,12,23,28,31, 41,42,45 C	a	Fn 2	2b,3
				All other values	1c

Contributors: (a) McGeorge, W. T. (b) Thornton, M. K. (c) Walker, R. H.

References: (1) Spurway, C. H., Mich. Agr. Exp. Sta. Special Bull. 396, 1941. (2) Thornton, M. K., Soil reaction preference of some plants, Texas A & M Agr. Ext. Leaflet. (3) Food and Agricultural Organization, Agricultural studies 9, 1949.

Reviewers: Jenny, H.; McGeorge, W. T.; Pohlman, G. G.; Thornton, M. K.; Walker, R. B.; Wherry, E. T.

65. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: FOODSTUFFS OF ANIMAL ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fns 2,3	1	30 H	1ac	54 H	4ac
Fn 4	1	31 A-H	1	55 AB	1c
1,2 AB	1c	32 A-E G	1	55 C-H	1
1,2 C-H	1	32 F H	1c	56 AB	1c
3,4 A-H	1c	33 A-H	4e	56 C-G	1
5 A-H	1	34 AB	1c	56,57 H	1c
6 ABC E-H	1c	34 C-H	1	57 AB	1c
6 D	1	35 A-H	1	57 C-G	1
7,8,9 AB	1c	36 C-G	1	58,59,60 A-H	3
7,8,9 C-H	1	36 AB	1c	61 A-H	5a
10 A-H	1	36,37 H	1ac	62 A-D	1c
11 AB	1c	37 AB	1c	62 E-H	1
11 C-H	1	37 C-G	1	63 AB	1c
12 A-G	1c	38 AB	1c	63 C-H	1
12 H	1abcd	38 C-G	1	64 AB	1c
13 AB	1c	38 H	1ac	64 C-H	1
13 C-H	1	39,40 A-H	1	65 AB	1c
14 A-H	1	41 C-H	1	65 C-H	1
15 AB	1c	41 AB	1c	66 AB	1c
15,17 C-H	1	42 A-H	2e	66 C-H	1
16 A-H	1	43 A-H	5a,e	67 AB	1c
17 AB	1c	44 A-H	3	67 C-H	1
18,19 A-H	1	45 A-H	4e	68 A-H	1
20 AB	1c	46 A-H	2	69 A-F	1c
21,22 A-H	1	47 AB	1c	69 GH	1
23,24 A-H	2	47 C-H	1	70 AB EF	1c
25 A-H	1e	48 A-H	4e	70,71 CD GH	1
26 A-F H	1c	49 A-G	4e	72 A-H	1
26 G	1	49 H	4a	73 AB	1c
27 AB	4de,5a	50 A-H	2	73 C-H	1
27 C-H	5a	51 AB	1c	74 A-H	1
28 AB H	1c	51 C-G	1	75 A-H	5
28 C-G	1	51 H	1ac	76 A-H	1
29 AB	1c	52 AB	1c	77 C-H	1
29 C-H	1	52 C-H	1	77 AB	1c
30 AB	1c	53 A-H	1	79 A-H	1
30 C-G	1	54 A-G	4e	80 A-H	2e

Contributors: (a) Binkerd, E. F. (b) Bray, H. W. (c) Ives, M. (d) Kochakian, C. D. (e) Wooster, H. A., Jr.

References: (1) Watt, B. K., and Merrill, A. L., U. S. Dept. Agr. Handbook 8, 1950. (2) Wooster H. A., Jr., and Blanck, F.C., Nutrition data, Pittsburgh: H. J. Heinz Co., 1950. (3) Leung, W. W., Pecot, R. K., and Watt, B. K., U. S. Dept. Agr. Handbook 34, 1952. (4) Table of food values recommended for use in Canada, Department of National Health and Welfare, Ottawa, 1951. (5) Chatfield, C., and Adams, G., U. S. Dept. Agr. Circ. 549.

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66. MINERAL AND VITAMIN COMPOSITION: FOODSTUFFS OF ANIMAL ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 B-I	1,3	34-37 B-I	1,2	56-61,66,67,69,70 B-I	1,2
Fn 5-8, 10	3	41-43 B-I	2	68 B	2
7,9 B-I	1,3	44,46 B-I	3	68 C-I	1,2
12,16-18 B-I	1,2	47 B-I	1,2	71 B-I	2
23,24 B-I	3	50 B-I	3	73 B-I	3
25,27,29,31 B-I	1,2	51,52 B-I	1,2	All other values	1
32 B-I	2	53-55 B-I	2		

Data contributed and adapted from (1) Watt, B. K., and Merrill, A. L., U. S. Dept. Agr. Handbook 8, 1950; (2) Leung, W. W., Pecot, R. K., and Watt, B. K., U. S. Dept. Agr. Handbook 34, 1952; and (3) Wooster, H. A., Jr., and Blanck, F.C., Nutritional data, Pittsburgh: H. J. Heinz Co., 1950.

Reviewers: Binkerd, E. F.; Bray, H. W.; Ives, M.; Kochakian, C. D.; Shinn, B. M.; Watt, B. K.; Wooster, H. A., Jr.

67. CHEMICAL COMPOSITION OF MILK

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
6 B-D G-I	2a,3a,4a,5a	35 G	5a	44 B-I	5a
13 B F H J	Calc fr 1 by a	36 B-E G	5a	Fn 5	6a,7a
14 B-G I	Calc fr 1	43 C E G I K	5a	All others	1
33 B-D G I	5a				

Contributor: (a) Hoobler, I. M.

References: (1) The composition of milks, Bull. of the National Research Council, 254, Jan, 1953. (2) Duncan, C. W., et al., J. Dairy Sci. 35:128, 1952. (3) Miller, S., et al., J. Nutrition 40:499, 1950. (4) Miller, S., and Ruttinger, V., Proc Soc. Exp. Biol. Med. 77:96, 1951. (5) Children's Fund of Michigan, Research Laboratory (unpublished data). (6) Lesher, M., Brody, J. K., Williams, H. H., and Macy, I. G., Am. J. Dis. Children 70:182, 1945. (7) Lesher, M., et al., J. Am. Dietetic Assoc. 23:211, 1947.

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68. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: FOODSTUFFS OF PLANT ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 3,4,5	7b	50 F	3a,7a	41,45 J	1a,2a,3a,5a,6a,7a
Fn 6	a	3 G	1a,2a,7ab	56 J	1a,2a,3a,6a,7a
92 BC	8	11,15,17 G	1a,2a,3a,6a,7ab	60,69,73 J	1a,2a,5a,6a,7a
4,12,13,15,17,22, 23,48,49,53,64, 74,77-80,83-85,		12 G	1a,2a,3a,5a,6a, 7ab	62,64,75 J	1a,2a,6a,7a
				77 J	1a,3a,4a,6a,7a
		16 G	1a,2a,3a,4a,5a, 6a,7ab	91 J	1a,2a,3a,6a,7a
87,91,93 C	7ab			1-4,6,8,11-13, 15-18 K	1a,2a,7ab
2,3,5,19,21,24, 26 D	3a,4a,7a	20 G	1a,2a,3a,7ab	19 K	2a,7ab
29,31,34 D	3a,7a	31,42 G	1a,2a,6a,7ab	21,23,24,26,29-32, 34-36,38 K	1a,2a,7ab
32,37,39,42,47,56, 57,59,61,63,67,		37 G	1a,2a,3a,6a,7ab	39 K	1a,7ab
		43,57 G	1a,2a,3a,7ab	41,42,45,47 K	1a,2a,7ab
68,89 D	3a,4a,7a	48 G	2a,3a,7ab	43,49,50 K	2a,7ab
51,65,72,94 D	3a,7a	51,53,56,58,65, 68,72,84 G	1a,2a,3a,6a,7ab	51,53,56-59,61, 63-65,67-69,	
90 D	3a,5a,7a	62 G	1a,2a,3a,4a,5a, 6a,7ab	71,72,76 K	1a,2a,7ab
13,15,17 E	1a,2a,3a,6a,7ab			77 K	1a,7ab
30 E	1a,2a,3a,4a,5a, 6a,7ab	88 G	1a,2a,6a,7ab	78,83-85,87-90,K	1a,2a,7ab
		90,94 G	1a,2a,3a,6a,7ab	80 K	7ab
43 E	7ab	92 G	8	92 K	1a,2a
45 E	1a,2a,3a,5a,6a,7ab	2,16 H	1a,2a,3a,6a,7a	93,94 K	1a,2a,7ab
48 E	2a,3a,7ab	19,23 H	1a,2a,3a,5a,6a,7a	1,3,8,12-18 L	2a,7ab
84 E	1a,2a,3a,6a,7ab	62 R	1a,2a,3a,4a,5a,6a	11,19,24,27 L	7ab
92 E	8	65,71 H	1a,2a,3a,6a,7a	20-22,29-38 L	2a,7ab
1 F	1a,2a,3a,4a	3 I	1a,2a,6a,7ab	39,56 L	7ab
3,16,19 F	1a,2a,3a,4a,5a, 6a,7a	80 I	7ab	40,42,43,45-47, 49-51,53-55,57- 65,67-69,71-73,	
		3 J	1a,2a,6a,7a		
4 F	1a,2a,3a,5a,6a,7a	4 J	1a,2a,5a,6a,7a		
5,6 F	1a,2a,3a,4a,6a,7a	5 J	1a,2a,3a,6a,7a		
7 F	3a,6a	11 J	1a,3a,7a		
26 F	1a,2a,3a,4a,5a,7a	19,20,23 J	1a,2a,5a,6a,7a	75,76 L	2a,7ab
32,33 F	1a,2a,3a,4a,5a, 6a,7a	22 J	2a,3a,6a,7a	77,80,81 L	7ab
		26 J	1a,2a,3a,5a,7a	78,79,83-90,93 L	2a,7ab
36 F	1a,2a,3a,4a,6a,7a	29,34 J	1a,2a,3a,6a,7a	92 L	2a
46,62,67,73 F	1a,2a,3a,4a,5a, 6a,7a	35,40 J	1a,2a,6a,7a	All other values	7b

Contributors: (a) Lucas, E. H. (b) Watt, B. K., and Merrill, A. L.

References: (1) Chaney, M. S., and Ahlborn, M., Nutrition, Boston: Houghton-Mifflin Co., 1943. (2) H. J. Heinz Co., Nutritional charts, Pittsburgh: H. J. Heinz Co., 1940. (3) Mattice, M. R., Bridges' food and beverage analyses, Philadelphia: Lea & Febiger, 1950. (4) McCance, R. A., and Widdowson, E. M., Chemical composition of foods, London: Medical Research Council, 1946. (5) Mottram, V. R., and Radloff, E. M., Food tables, London: Edward Arnold & Co., 1937. (6) Sherman, H. C., and Lanford, C. S., Essentials of nutrition, New York: Macmillan Co., 1943. (7) Watt, B. K., and Merrill, A. L., U. S. Dept. Agr. Handbook 8, 1950. (8) Wooster, H. A., Jr., and Blanck, F. C., Nutritional data, Pittsburgh: H. J. Heinz Co., 1950.

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Data Coordinates and Footnotes	Contributors and References
1-91,93-95 B	8d
92 B	12
2,3,6,14 C	1c,2c,3c,4c,5c,6c, 7c,8c
12,19 C	1c,2c,3c,4c,7c,8c
20 C	1c,2c,3c,4c,6c,7c, 8c
26 C	2c,3c,6c,7c,8c
27 C	1c,4c,5c,6c,7c,8c
29 C	1c,2c,3c,4c,7c,8c
30-32 C	1c,2c,3c,4c,5c,6c, 7c,8c
34 C	1c,2c,3c,4c,7c,8c
37,41,47 C	1c,2c,3c,4c,5c,6c, 7c,8c
45 C	1c,2c,3c,4c,7c,8c
48 C	1c,3c,4c,8c
49 C	1c,3c,4c,7c,8c
56,58,59 C	1c,2c,3c,4c,5c,6c, 7c,8c
57 C	1c,2c,5c,8c
65 C	1c,2c,3c,4c,7c,8c
63,67-69,71,72, 75 C	1c,2c,3c,4c,5c,6c, 7c,8c
80 C	1c,4c,5c,8c
86,89,93 C	1c,2c,3c,4c,5c,6c, 7c,8c
91 C	1c,2c,3c,4c,7c,8c
1 D	5ec
2 D	1c,4c,5ec,13e
3 D	1c,4c,5c
4 D	1c,4c,13e
5 D	1c,5c,13e
6 D	1c,4c,5ec
7 D	5e
8,9,11,15 D	1c,4c
12 D	1c,4c,13e
14,16 D	1c,4c,5ac
18-20 D	1c,4c
23 D	1c,4c,13e
21,24,27,31-33 D	1c,4c,5c
24,27,31,32 D	5e
26 D	5ab
29 D	4c
30 D	1c,4c,5c,13e
34 D	1c,4c
35-39 D	1c,4c,5c
36,37,39 D	5a
40 D	1c,5ec
42,46 D	1c,4c,5c
45 D	13e
42,46,47 D	5a
47 D	1c,3c,4c,5c
48-50 D	1c,4c
52 D	5e
56 D	1c,4c,5ac
58-60 D	1c,4c,5c
61 D	1c,4c,5c,13e
57 D	5ac
62,64-66 D	1c,4c
62,63,65 D	13e
63 D	1c,4c,5c
67,69,71,72 D	1c,4c,5ac
68 D	4c,5c
73,79,80 D	1c,4c
75,78 D	1c,4c,5c
77,80,83 D	13e
83 D	4c
86,88,89 D	1c,4c,5ec
87 D	13e
87,91 D	1c,4c
90 D	5ec
93 D	1c,4c,5c
94 D	1c,4c
3 E	10f
11-13 E	11f
19 E	10f,11f
21,26,31 E	10f
29 E	10f,11f
39 E	10f
47 E	10f,11f
52,55,59,63,69, 78,89 E	10f
83 E	10f,11f
87,91 E	11f
93 E	10f
1 F	5ac
2,3,6 F	1c,3c,4c,5c
2,3,6 F	5a
4 F	1c,3c,4c
5 F	1c,3c,5c,13e
7 F	1c,4c,5a
8 F	3e
9,12,13,15 F	1c,3c,4c
14 F	1c,3c,4c,5ac
16 F	1c,2c,3c,4c,5ac
18-20,23,24 F	1c,3c,4c
21 F	1c,3c,4c,5ac
26 F	3c,5a
27 F	1c,4c,5ac
29 F	3c,4c
30-32 F	1c,3c,4c,5c
31,32 F	5a
33 F	1c,4c,5c
34 F	1c,3c,4c
35 F	1c,3c,4c
36,37,40,42,46,47 F	1c,3c,4c,5ac
39 F	1c,4c,5ac
43,45,49 F	3b
46 F	9b
48 F	3c
50 F	1c,4c
52,56,57,61 F	5a
53,60 F	1c,3c,4c
56-59,61 F	1c,3c,4c,5c
62 F	3c,4c,5e
63 F	1c,3c,4c,5c
64,65 F	1c,3c,4c
66 F	3b
67-69,71-73,75 F	1c,3c,4c,5c
67-69,71,72 F	5a
77 F	1c,4c
78 F	1c,4c,5c
79,84,87 F	1c,3c,4c
83,85 F	3c,4c
86 F	1c,4c,5ac
88,89 F	1c,3c,4c,5ac
90 F	3c,4c,5ac
91,94 F	1c,3c,4c
93 F	1c,3c,4c,5c
4 G	1c,4c
6 G	1c,4c
7 G	4c
20,24,29,30,35,42, 68,69,73,77,78, 89 G	1c,4c
26 G	5b
41,51 G	9b
1-76 H	8d
77 H	1c,2c,4c,6c,7c,8cd
78-91,93-95 H	8d
92 H	1c,2c,3c,4c
3 I	1c,2c,4c,5c,6c,7c, 8c
4 I	1c,2c,3c,4c,7c, 8c
5 I	1c,2c,3c,4c,5c,7c, 8c
6 I	1c,2c,3c,4c,5c,6c, 7c,8c
8,12,13,15 I	1c,2c,3c,4c,7c,8c
14,16 I	1c,2c,3c,4c,5c,6c, 7c,8c
18,19 I	1c,2c,3c,4c,7c,8c
20 I	1c,2c,3c,4c,6c,7c
21 I	1c,2c,3c,4c,5c,6c, 7c,8c
23 I	1c,2c,3c,4c,7c,8c
27 I	1c,4c,5c,6c,7c,8c
30,33,35,37 I	1c,2c,3c,4c,5c,6c, 7c,8c
34 I	1c,2c,3c,4c,7c,8c
37 I	5a
39 I	1c,2c,3c,4c,5c,6c, 7c,8c
43 I	1c,3c,4c,7c,8c
45 I	1c,2c,3c,4c,7c,8c
47 I	1c,2c,3c,4c,5c,6c, 7c,8c
50 I	1c,2c,4c,5c,6c,7c, 8c
53 I	1c,2c,3c,4c,7c,8c
56,58,59,63,68, 71,72 I	1c,2c,3c,4c,5c,6c, 7c,8c
78 I	1c,2c,4c,5c,6c,7c, 8c
80 I	1c,4c,5c,7c,8c
83 I	1c,2c,3c,4c,7c,8c
86,90 I	1c,2c,3c,4c,5c,6c, 7c,8c
88 I	1c,2c,3c,4c,5ec, 7c,8c
1,7 J	5c
2-6 J	5c,13e
12,15;13,23 J	13e;3b
14,16,21,24 J	5c,13e
18,26 J	5b
27,30-33,39-42,46J	5c
29,35-37,45 J	13e
47,56,58 J	5c,13e
49 J	3b
50,57,59,60,62,63J	5c
51,52 J	5eb
53 J	9b
61,67-69,71 J	5c,13e
64,77 J	13e
65,66 J	3b
72,75,86,88-90 J	5c
73,78,80,93 J	5c,13e
83 J	13e
84,85,87,94 J	5b
1,2,4,6,7,9,12 K	1c,4c
5 K	9b
13,14,15 K	1c,4c
16,18,19 K	1c,4c
20,21 K	1c,4c
23,24,27 K	1c,4c
29 K	4c
30,31,32 K	1c,4c
34-37 K	1c,4c
40 K	4c
41,42,45,46 K	1c,4c
47 K	1c
50,53,56-61 K	1c,4c
62 K	4c
63-65,67-69,71-73, 75,77-79,83,84, 86-89,91-94 K	1c,4c
85,90 K	4c
1-91,93-95 L	8d
2,3 M	1c,2c,3c,4c,5ac, 6c,7c,8c
5,14 M	1c,2c,3c,4c,5c, 7c,8c
13,15,19 M	1c,2c,3c,4c,7c,8c
20 M	1c,2c,3c,4c,6c,7c, 8c
21 M	1c,2c,3c,4c,5c,6c, 7c,8c
24 M	1c,2c,3c,4c,5ac, 6c,7c,8c
26 M	2c,3c,5e,6c,7c,8c
31-33,35,37,41, 42 M	1c,2c,3c,4c,5c,6c, 7c,8c
31,32,37,42 M	5a
43 M	1c,3c,4c,7c,8c
45 M	1c,2c,3c,4c,7c,8c
46,47,50 M	1c,2c,3c,4c,5ac, 6c,7c,8c
57 M	2c,5ec,8c
59,60-63 M	1c,2c,3c,4c,5c,6c, 7c,8c

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
61 M	5a	64-66 N	4c	5 P	1c,4c,5c,12e
65 M	1c,2c,3c,4c,7c,8c	67-69,71,72,75 N	4c,5ac	7 P	5e
67-69,71,86,89,90M	1c,2c,3c,4c,5ac, 6c,7c,8c	75 N	4c,5c	12,15 P	13a
		73,78,80 N	5c	16 P	1c,4c,5ac,13e
73,75 M	1c,2c,3c,4c,5c,6c, 7c,8c	77,79,83-85,87 N	4c	19 P	1c
		86,89,90 N	4c,5ac	20 P	1c,4c
77 M	1c,2c,4c,7c,8c	88 N	5ac,14e	23,26 P	5b
80 M	1c,4c,5c,8c	91 N	4c	21,24,27,31,32,	
83,87 M	1c,2c,3c,4c,7c,8c	92 N	5ac	36,39 P	1c,4c,5ac
91 M	1c,2c,3c,4c,7c,8c	94 N	5c	29 P	13e
93 M	1c,2c,3c,4c,5c,6c, 7c,8c	1,3,6 O	4c,5ac	30 P	1c,4c,5c,13a
91 M		2,4,8,9,12-15 O	4c	33,35,41 P	1c,4c,5c
94 M	1c,3c,4c,7c,8c	5 O	4c,5a	37 P	1c,4c,5ac,13e
1,2,3,6 N	4c,5ac	7 O	5a	40,42,47,50 P	1c,4c,5ec
4,8,9 N	4c	16 O	4c,5ac	45 P	13e
5 N	4c,5c	18-20,22,23 O	4c	46 P	1c,4c,5ec,13a
7 N	5a	21 O	5ac	52 P	5e
14,16 N	4c,5ac	24,27 O	4c,5ec	53 P	13e
12,13,15,18-20,		26 O	5b	56 P	1c,4c,5ac
22,23 N	4c	29 O	4c	58 P	1c,4c,5c,13e
21 N	5ec	30,33 O	4c,5c	61 P	1c,4c,5ac,13e
24 N	4c,5ec	31,32 O	5ac	62 P	1c,4c,5c
26 N	5b	34 O	4c	63 P	1c,4c,5bc
27,30,32,33 N	4c,5c	35 O	5c	66 P	3b
29 N	4c	36,37,39,40,42,		67-69 P	1c,4c,5ac
31 N	5ac	46,47,50 O	4c,5ac	71 P	1c,4c,5ac,13e
32 N	5e	41 O	4c,5c	72 P	1c,4c,5ac
34 N	4c	51,53 O	4c	73,75,78 P	1c,4c,5c
35,41 N	5c	52,56,57 O	5a	80,83,91 P	13e
36,37,39,42,46,47N	4c,5ec	56,58,60 O	5c	86,88-90 P	1c,4c,5ac
40 N	5ec	57,59 O	4c,5c	87,94 P	5b
45 N	4c	61,64-69,72 O	4c	93 P	1c,4c,5c
49 N	5b	62,63 O	4c,5c	2,3,4,6,12,13,	
50 N	4c,5ac	71 O	5ac	19-21,23 Q	9c
51,53 N	4c	73,78 O	5c	26 Q	9b
52 N	5a	75,77,79,83-85,		31-35,39,41,46,47,	
56 N	5ac	87,91,92,94 O	4c	50,56,61,63,67-69,	
57 N	4c,5ac	86,89,90 O	4c,5ac	72,79,83,85-91 Q	9c
58,60 N	5c	88 O	5ac	49 Q	9b
59 N	4c,5c	92 O	5a	77 Q	5b
61 N	4c,5ac	93 O	4c,5c	78 Q	3b
62,63 N	4c,5c	1,2,3,6,14 P	1c,4c,5ec		

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-21,23-26 B	6c	34 E	1a,2a,3a,4a,6a	23-26,28-32 H	6ac
27 B	6ac	36,37,41,42 E	1a,2a,3a,4a,5a,6a	34 H	1a,4a,6ac
28-45 B	6c	43 E	1a,3a,4a,5a,6a	35-39,41-65 H	6c
46 B	3a,6ac	45 E	1a,2a,3a,4a,5a, 6a,7a	66 H	6ac
47-49 B	6c			67-75 H	6c
50 B	2a,3a,6ac	46,47 E	1a,2a,3a,4a,5a,6a	77 H	4a,6ac
51-91 B	6c	48,49 E	1a,3a,4a,6a	78-91,93-95 H	6c
92 B	2a,4a	50 E	2a,3a,4a,5a,6a	2,9 I	1a,2a,3a,4a,6a
93-95 B	6c	51 E	1a,2a,3a,4a,6a,7a	3-6 I	1a,2a,3a,4a,5a,6a
2,4,5 C	2a,3a,4a,5a,6a	56,61,65,67,69 E	1a,2a,3a,4a,5a,6a	12 I	1a,2a,3a,5a,6a
11,18 C	2a,3a,5a,6a	59,63,68 E	1a,2a,3a,4a,5a, 6a,7a	13,14 I	1a,2a,3a,4a,5a,6a
14 C	2a,3a,4a,5a,6a			18 I	1a,4a,6a
26,29,34 C	2a,3a,4a,6a	70 E	2a,3a,5a,6a	20 I	2a,3a,4a,5a,6a
30,36 C	2a,3a,4a,5a,6a	71,72,75 E	1a,2a,3a,4a,5a,6a	21,23,24,29 I	1a,2a,3a,4a,5a,6a
39 C	2a,4a,5a,6a	76,83 E	1a,2a,3a,4a,5a, 6a,7a	32 I	2a,3a,4a,5a,6a
40,45,51,57 C	2a,3a,4a,6a			31,36,37,41,59,61, 63,67,69 I	1a,2a,3a,4a,5a,6a
47,53,56 C	2a,3a,4a,5a,6a	79 E	1a,2a,3a,6a	60 I	1a,2a,3a,5a,6a
59 C	2a,3a,5a,6a	84 E	1a,3a,4a,6a	65,68 I	1a,2a,3a,4a,6a
67,70 C	2a,3a,4a,5a,6a	86,88-91,94 E	1a,2a,3a,4a,5a,6a	70 I	2a,3a,4a,5a,6a
68 C	2a,3a,5a,6a	87 E	1a,2a,3a,5a,6a	71,83-87,91,94 I	1a,2a,3a,4a,5a,6a
71 C	2a,3a,6a	1-15,17 F	6c	73,79 I	1a,2a,3a,4a,6a
74 C	2a,3a,5a,6a	18,20 F	6ac	1-91 J	6c
83 C	2a,3a,4a,6a	19,21 F	6c	92 J	2a,4a
84-86,89,94 C	2a,3a,4a,5a,6a	22 F	6ac	93-95 J	6c
1-20,23-91 D	6c	23-30 F	6c	1-4,6 K	1a,2a,3a,4a,5a,6a
92 D	2a,3a	31 F	6ac	12 K	1a,2a,3a,5a,6a
93-95 D	6c	32 F	6c	13 K	1a,2a,3a,4a,6a
2,4,8 E	1a,2a,3a,4a,5a,6a, 7a	34-39,41-48 F	6c	14,19-21,23,29 K	1a,2a,3a,4a,5a,6a
		49-51 F	6ac	16,33 K	2a,3a,4a,6a
3,5,6,11 E	1a,2a,3a,4a,5a,6a	52-57 F	6c	34 K	1a,2a,4a,6a
12 E	1a,2a,3a,5a,6a	58,64 F	1a,6ac	35,38 K	2a,3a,4a,5a,6a
14 E	1a,2a,3a,4a,5a,6a	59-63,65-87 F	6c	37,41,46 K	1a,2a,3a,4a,5a,6a
15 E	8b	88,90,93 F	6ac	40 K	2a,3a,4a
17,19,20 E	1a,2a,3a,4a,5a, 6a,7a	89,91,94,95 F	6c	43,49 K	1a,3a,4a,5a,6a
		2,17 G	1a,2a,6a	48 K	4a,6a
18 E	1a,2a,3a,5a,6a,7a	12,19 G	1a,2a,4a,6a	50 K	2a,3a,4a,5a,6a
21 E	1a,2a,3a,4a,5a,7a	13 G	1a,6a	56,59,61 K	1a,2a,3a,4a,5a,6a
23,29 E	1a,2a,3a,4a,5a, 6a,7a	21,23,29,32 G	1a,2a,6a	65 K	1a,2a,3a,5a,6a
		53 G	1a,6a	67-69,72,73,75 K	1a,2a,3a,4a,5a,6a
24 E	1a,2a,3a,5a,6a,7a	62,69 G	1a,2a,4a,6a	81 K	1a,2a,4a,6a
26 E	8b	65,68,73,81,87 G	1a,2a,6a	83,87,89,90,93, 94 K	1a,2a,3a,4a,5a,6a
30,32 E	1a,2a,3a,4a,5a,6a	91 G	1a,6a		
31 E	1a,3a,4a,5a,6a	1-15,17-21 H	6c		
33 E	2a,3a,4a,5a,6a	22,27 H	6ac		

Contributors: (a) Lucas, E. H. (b) Smock, R. M. (c) Watt, B. K., and Merrill, A. L.

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71. PROXIMATE CHEMICAL COMPOSITION AND ENERGY VALUES: TROPICAL AND SUBTROPICAL FRUITS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1	5	13 DE G I M O Q S U W BB	3b,4a	27 F N P R T V X Z CC	1c
1,8,9,13 B	1c	13 JK	4a	27 DE GHI LM O Q U W Y BB EE FF	3b,4a
2,3,4,10-12,14, 16-21,24-31,33, 34,37,38 B	2c	14 DEF HIJ L NO	4a	27 JK	4a
5,7,35,36,40 B	Calc. fr col. F-K & Fn 1	15 D F J L N P R T V X Z CC EE	1c	28 D F H J L N P R T X	2c
2,3,5,7,13,14,16, 20,25,26,28,30, 33-36,40 C	Calc. fr col. F-K & Fn 1	15 E GHI M O S U Y BB FF	3b,4a	29 D F H J L P R T V X Z EE & Fn 6	1c
1 D F H J L N P R T V X Z CC EE	1c	15 K	4a	29 E G I MNO Q S U W Y-DD FF	3b,4a
1 G M O Q S U W Y BB DD FF	3b,4a	16 D J L N P R T V X Z CC EE	1c	29,30 K	4a
2 D F H J L N P T V X Z CC EE	1c	16 F-I M S U FF	3b,4a	30 D F H J L N P R V X Z CC	1c
2 E G I M O Q R S U W Y BB DD FF	3b,4a	17 D F H J L N P R T V X	2c	30 E G M O S Y EE FF	3b,4a
3,4 D F H J L N P R T V X Z CC EE	2c	18 D F H J L N P R T X CC	2c	31 D F H L N P R T V X Z CC EE	3b
3 E G I M O Q S U W Y DD FF	3b,4a	19 D F H J L N P T V X Z CC EE	2c	32 D F H J L N P R T V X Z CC EE	2c
5 D-I LMN P-EE	3b,4a	19 E G I M O Q U Y DD FF	3b,4a	32 E G I M O Q S U W Y DD FF	3b,4a
5 JK	4a	19 K	4a	32,33 K	4a
6 D F H L N P R T X Z CC EE	3b	20 D F H J L N P R T X EE	2c	33 D F H J L N P T V X Z CC	2c
7 D-I L-V X-FF	3b,4a	21 D F GHI L N P-FF	3b	33 E G I M O R S Y BB DD EE	3b,4c
7 JK	4a	22 D F H L N P T X Z CC EE	3b	34,35 D-I L-EE	3b,4a
8,9 D F H J L N P R T V X Z CC EE	2c	23 D F J N P T V X Z	2c	34,35 K	4a
10 D F H J N P R T V X Z CC EE	2c	23 GH LM O QRS W BB CC EE FF	3b,4a	36 D F H J L P T V X Z	2c
10 E G L M O Q U	3b	24 K	4a	36 G MNO QRS U BB-EE	3b
11 D F H J L N P R T V X Z CC EE	2c	24 F J N P R T V X EE & Fn 5	2c	37 D F H L N P R T V X EE	2c
11 E G I M Q S U W Y BB DD	3b	24 DE GHI LM O Q S U W Y-DD FF	3b,4a	37 E G I J D Z-DD FF	4a
12 F J L M P R T V X Z	1c	25 H J P R T V X	1c	38,40 D-I L-FF	3b
12 DE GHI NO Q U W Y BB-FF	3b	25 D-G L-O Q U W Y-FF	3b,4a	39 D-Z CC-FF	4a
12 K	4a	25 K	4a		
13 F H L N P R T V X Z CC EE	1c	26 D F H J L N P R T V X Z CC EE	1c		

Contributors: (a) Asenjo, C. F. (b) Harris, R. S. (c) Phipard, E. F.

References: (1) Watt, B. K., and Merrill, A. L., U. S. Dept. Agr. Handbook 8, 1950. (2) Leung, W. T., Pecot, R. K., and Watt, B. K., U. S. Dept. Agr. Handbook 34, 1952. (3) Farris, R. S., and Munsell, H. E., Composition of the edible plants of Central America (unpublished). (4) Asenjo, C. F., Puerto Rico Rev. Agr., 1953. (5) U. S. Dept. Agr., Table of food consumption for the armed forces.

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72. RELATIVE PRODUCTION OF NUTRIENTS: FOODSTUFFS OF PLANT ORIGIN

Reference: Data contributed by Christensen, R. P., from Christensen, R. P., U. S. Dept. Agr. Tech. Bull. 963, 1948.

Reviewers: Bradley, W. B.; Christensen, R. P.; Frey, C. N.; Ives, M.; Kochakian, C. D.; Nelson, E. M.; Proctor, B. E.; Watt, B. K.; Wells, S.

73. AMINO ACID COMPOSITION: CERTAIN PROTEIN FOODS

Contributor: (a) Cole, W. H.

Reference: (1) Adapted from a Report on cooperative determinations of the amino acid content, and of the nutritive value of six selected protein food sources, Bureau of Biological Research, Rutgers University, New Brunswick, New Jersey, 1950.

Reviewers: Cole, W. H.; Harte, R. A.; Howe, E. E.

74. PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF ANIMAL ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 5,6,7	b	8 I M	3c	17 D-I	1b,3c
1 B-I M	1b	9,11,12 B-I M		17 M & Fn 35	1b
2 B-H	2b,3c	& Fn 24	2b	18 B-I M & Fn 37	2b
2 I M	3c	Fn 23	5d	2,3,5,8,10,13,14,	
3 BC I M	3c	10 B-I M	2b,3c	17 JKL	Calc. fr 3 by a
3 D-H	2b,3c	13 B-H	1b,3c	Fn 11,21	a
4 B-H M & Fn 12	1b	13 I M	3c	Fn 8,9,10,13-15,	
5 B-I	2b,3c	14 B-I M	2b,3c	17,22,26-31	Calc. fr 4d
5 M	3c	Fn 32	2b	1-18 N	Calc. fr Fn 6 by a
6,7 B-I M & Fn 18	2b	Fn 33	5d	1-18 O & Fn 12,20,	
Fn 16,19	5d	15,16 B-I M	1b	25,34,36,38	Calc. fr Fn 7 by a
8 B-H	2b,3c	17 BC I	3c		

Contributors: (a) Miller, D. F., (b) Norris, L. C., (c) Schneider, B. H., (d) Tillman, A. D.

References: (1) Morrison, F. B., Feeds and feeding, Ithaca, N. Y.: Morrison Publishing Co., 1948. (2) Committee on Feed Composition, as published in various pamphlets on nutrient allowances for domestic animals, National Research Council, Washington, D. C., 1949-51. (3) Schneider, B. H., Feeds of the world, their digestibility and composition, Morgantown, W. Va.: Univ. W. Va. Press, 1947. (4) Fraps, G. S., Texas Agr. Exp. Sta. Bull. 663, 1944. (5) U. S. Dept. Agr. Yearbook, 1939.

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75. MINERAL AND VITAMIN COMPOSITION: FEEDSTUFFS OF ANIMAL ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-F H-K	2a	8 B-F H JK	1b	14 B-F H-K	2b
2,4 B-F HIJ	2a	9 B-F J	1b	15 B F	b
3 B-F H-K	1b	9 HI K	1a	16 B F K	2a
5 B EF HIJ	2a	10 B EF H JK	1b	16 CDE HIJ	2b
6 B F IJ	2b	11 B-F H-K	1b	17 B-F H-K	2a
6 CDE	2a	12 B EF HIJ	1b	17 CDE	2b
7 B F	b	13 B E-K	b	18 B-F H-K	1b

Contributors: (a) Miller, D. F. (b) Norris, L. C.

References: (1) Committee on Feed Composition 1949-51, as published in various pamphlets on nutrient allowances for domestic animals, National Research Council, Washington, D. C. (2) Committee on Feed Composition, Composition of feeds, supplement to report 1, National Research Council, Washington, D. C., 1947.

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76. PROXIMATE CHEMICAL COMPOSITION, ENERGY VALUES AND DIGESTIBLE NUTRIENTS: FEEDSTUFFS OF PLANT ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-H	1b	25,27 B-H	1b,3c	60,62-64,66,68,69 B-I M	1b
2 B-H	1b,3c	25,27 I M	3c	70,71,77,81 B-I M	3c
2 I M	3c	Fn 30,44	1b	72-76,78,80 B-I M	2b
Fn 8	1b	28 B-I	1b,3c	2,6,8,9,14-16, 21-30,33,36-39, 41,43,44,50-52, 55,58,59,61-63, 65,67,68,70-81 JKL	Calc. fr 3 by a
3 B-H	1b	28 M	3c	Fn 25	a
4,5 B-I M & Fn 14	1b	29,30 B-H	1b,3c	4,5,11,13,20,34, 40,45-47,49,54, 56,57,60,64,66, 69 JKL	Calc. fr 1d
6 B-I	1b,3c	Fn 23	1b	Fn 10-13,16-22, 34-37,40-43,46, 47,48-53,56-59, 62-65	Calc. fr 4d
6 M	Calc. fr 3 by a	29 I M	3c	2,4-81 N	Calc. fr Fn 6 by a
7 B-I M	1b	30 M	Calc. fr 3 by a	2,4-81 O & Fn 9,15, 24,27,29,31,33, 39,45,55,61,67, 69	Calc. fr Fn 7 by a
8,9 B-H	1b,3c	31 B-I M	1b		
8,9 I M	3c	32 B-E HI M & Fn 54	1b		
10-13 B-I M & Fn 23	1b	32 F	b		
14 B-I M	3c	33 B-I	1b,3c		
Fn 25	a	33 M	3c		
15 B-H	1b,3c	34,35 B-I M & Fn 60	1b		
15 I M	3c	36,37,39 B-H	1b,3c		
Fn 26	1b	36,37,39 I M	3c		
16-20 B-I M & Fn 28,30	b	Fn 66,68	1b		
21-23 B-H	1b,3c	38 B-I M	3c		
21-23 I M	3c	40-42,45-54 B-I M	2b		
Fn 32,38	1b	43,44,55 B-I M	3c		
24,26 B-I M	3c	56-58 B-I M	2b		
		59,61,65,67 B-I M	3c		

Contributors: (a) Miller, D. F., (b) Norris, L. C., (c) Schneider, B. H., (d) Tillman, A. D.

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77. MINERAL AND VITAMIN COMPOSITION: FEEDSTUFFS OF PLANT ORIGIN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 B-K	2c	19-22 B-F H-K	2c	53 B F G	1c
3 G	2c	24 B F H-K	1b	54 B D F	1c
3 J	2c	25,27,28 B F H-K	2c	55 B D F	1b
4,5 B-F H-K	2c	26 B-F H JK	1b	56,57 B DEF	1c
6 B F	c	29 B K	2b	58 B-F	1c
6 CDE H-K	3a	29 C-J	2c	59 B F	1b
7 B-F H-K	2c	30 B F	4c	60 B F G	1c
8 BF	c	30 CDE H-K	4b	61 B-F	1b
8 CDE H-K	3a	31 B-F J	2c	62 B EF G	1c
9 B-F H-K	4b	32 B DEF H-K	2c	63 B F G	1c
9 CDE G	4c	32 C	2b	64 B DEF	1c
10 F	c	33-39 B-F H-K	2c	64 G	3a
11 B-K	2c	40 B-K	1c	65 B-F	1b
12 B F H J K	4c	41 B F-K	1c	66 B FGH JK	1c
12 CDE I	4b	42 B E-K	1c	67 B-F	1b
12 G	3a	43 B-F I	1b	68 B F	1c
13 B-J	2c	45 B EF H	1c	69 B-F	1c
13 K	4c	46 B-F	1c	72 B-G	1c
14 B F J	1b	46 G	3a	73,74 B FG	1c
15 B-F H-K	2c	47 B EF	1c	75 B-H	1c
16 B D	2c	48 B DEF	1c	76 B F	1c
16 C E F H-K	4b	49 B-K	1c	77 B D F	1b
17 B EF H-K	2c	50 B-G	1c	78 G	1c
18 B-F H-K	2c	51 B-F	1c	79 F	1c
18 G	3a	52 F	1c	80 B EFG	1c

Contributors: (a) Ellis, N. R., (b) Miller, D. F., (c) Norris, L. C.

References: (1) Morrison, F. B., Feeds and feeding, Ithaca, N. Y.: Morrison Publishing Co., 1949. (2) Committee of Feed Composition, as published in various pamphlets on nutrient allowances for domestic animals, National Research Council, Washington, D. C., 1949-51. (3) U. S. Dept. Agr., Bureau of Animal Industry, (unpublished data). (4) Committee on Feed Composition, Composition of feeds, supplement to report 1, National Research Council, Washington, D. C., 1947.

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B E G & Fn 2	1b,2b	7 H & Fn 16	41b	14 B-E G & Fn 30,31	15b,54b
1 F & Fn 3	1b,57b	8 B-E G & Fn 18,19	21b,22b	15 B	8b
1 H	3b	8 F & Fn 20	23b	15 C E & Fn 33	7b
2 H	58a,3b	8,9 H	11b	15 D & Fn 34	8b
2 B-G & Fn 4	1bc,33bc,34bc	9 B	b	15 F & Fn 35	7b,9b,10b
3 B	19b	9 C-F & Fn 21	30b	15 G & Fn 36	b,8b
3 C-E & Fn 5	20abc	10 BC E	42b	15 H	3b,11b
3 EF H & Fn 6	11b	10 D & Fn 22	43b	16 B-D & Fn 37-39	4b
4 B D	b	10 F	44b	16 F	5b
4 C & Fn 7	31b	10 G	55b	16 G & Fn 37-39,41	4b,6b
4 EF	32b	11 B-D G & Fn 24	12b,13b,14b	16H	3b
5 B-D G & Fn 9	24b	11 EF	b	17 BC	b
5 EF	59b	11 H	3b,11b	17 D G & Fn 42	45b,46b
6 B & Fn 11	35b	12 B-D & Fn 25	17b	17 EF & Fn 43	47b
6 D & Fn 12	36b	12 G	18b	17 GH & Fn 44	48b
6 E	36b,37b,38b	12 H	11b	18-25 B E GH	b
6 F & Fn 13	37b,38b	13 B & Fn 26	26b	18-22 C	b
6 G	18b	13 C & Fn 27	27b	18-22,24,25 D & Fn 45	49b,50b
6 H	37b	13 DE G & Fn 28	56b,60b,61b	23 D	62b
7 B D	39b	14 B D F & Fn 32	15b,16b,54b	22,24 F & Fn 46	53b
7 C FG & Fn 14,15	40b			26 B-H	b

Contributors: (a) Cheldelin, V. H., (b) Frieden, E., (c) Snell, E. E.

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79. FOOD NUTRIENT LOSSES IN COOKING

Data Coordinates and Footnotes	Contributors and References
1-31 ABCDEFGHIJK 32-41 ABCDEFGHIJK	1b 2a

Contributors: (a) Crampton, E. W. (b) Robinson, A. D.

References: (1) Table of food values recommended for use in Canada, Ottawa: Dept. of Health and Welfare, 1951, collected from: Cheldelin, V. H., Woods, A. M., and Williams, R. J., J. Nutrition 26:477, 1943; Cooperman, J. M., and Elvehjem, C. A., J. Am. Dietet. Assoc. 21:155, 1945; Delorey, M. H., Brodie, J., and Willard, A. C., J. Canad. Dietet. Assoc. 6:6, 1944; Table of vitamin losses in cooking, Washington, D. C.: National Research Council, 1944; Oser, B. L., Melnick, D., and Oser, M., Food Research 8:115, 1943; Pett, L. B., Canad. J. Res. B 20:274, 1942: Russell, W. C., Taylor, M. W., and Beuk, J. F., J. of Nutrition 25:275, 1943; Simpson, J. I., Food Research 8:353, 1943; Adams, C. and Smith, S. L., U. S. Dept. Agr. Misc. Publ. 536, 1944; Van Duyne, F. O., Chase, J. T., and Simpson, J. I., Food Research 10:72, 1945. (2) Table of food values recommended for use in Canada, Ottawa: Dept. of Health and Welfare, 1951, collected from sources in reference (1) plus Cover, S., McLaren, B. A., and Pearson, P. B., J. Nutrition 27:363, 1944; Hiltz, M. C., Robinson, A. D., and Levinson, A., J. Canad. Dietet. Assoc. 5:85, 1943; Jackson, S. H., Crook, A., Malone, V., and Drake, T. G. H., J. Nutrition 29:391, 1945; McIntire, J. M., Schweigert, B. S., and Elvehjem, C. A., J. Nutrition 26:621, 1943; McIntire, J. M., Schweigert, B. S., Henderson, L. M., and Elvehjem, C. A., J. Nutrition 25:143, 1943; Schweigert, B. S., McIntire, J. M., and Elvehjem, C. A., J. Nutrition 26:65, 1943.

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80. APPARENT DIGESTIBILITY AND ABSORBABILITY OF NUTRIENTS: VERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BCD	1c	12,34 H	7h,8h,9h,11h,12h, 13h	20 I KL	6g,d
2,3,6,7,9,11 MNO	5i			23 I-L	6,d
4 BCD	2e	12 MN	5i	23,24,27,31-33, 38 MNO	5i
5 D	1c,2e	12,34 O	5i	28-30,35,36 BCD	2e
8 B D	2e	15 E-H	6f,d	32 E-L	6,d
10 BCD	2e	15 I-L	6,d	37 C	2e
10,11 EGH	6f	15,16,18,19 MNO	5i	41,42,44 E-H	6f
10 I KL	6fg	16 E-H	6,d	43 E-H	6f,d
12 BC	1c	17,18,21,22,25, 26 BCD	2e	46 E G	4g,6
12,34 D	1c,2e	18 I-L	6,d	47 MNO	5i
12 E	4c,6f	19 E-H	6a,d	49 I-L	6g,d
12 FG	8h,9h,10h,11h,12h, 13h	20 E-H	6,d	Fn 2	3b
				All other values	6

Contributors: (a) Couch, J. R. (b) Mattil K. F. (c) Maynard, L. A. (d) Pearson, P. B., Winchester, C. F., and Earle, I. P. (e) Phipard, E. F. (f) Swanson, E. W. (g) Thomas, J. W., and Moore, L. A. (h) Tillman, A. D. (i) Tomhave, A. E., and Mellen, W. J.

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81. CALORIE VALUES OF NUTRIENTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-G	1f,8f	4 L O	Calc. fr (1 L O minus 3 L O)	9 B-R	Calc. fr (8 B R)
1 B-K	1g,8	4 MN	Calc. fr 1-3 MN	10 B-E	Calc. fr (4 B-E minus 7 B-E)
1 L	4ch,8i	4 P R	10j,11j	10 FG	1f,8f
1 MN	9e	4 Q	Calc. by be	10 HI	g
1 O & Fn 4	9i,17,18	5 B-R	Calc. fr (4 B-R and 1 B-R)	10 L-O	Calc. fr (4 L-O minus 7 L-O)
1 PQR	10j,11j	6 B-G & Fn 16,17, 18	1b,8b	10 PQR	Calc. fr (4 PQR minus 7 PQR)
3 MN	Calc. fr 9	6 HI	Calc. fr (5 HI)	11 B-G	Calc. fr (10 B-G & Fn 16,17,18)
3 B-G	1f,8f	6 L-O & Fn 19	17,18	11 HI	Calc. fr (10 HI & Fn 25)
3 H	5g	Fn 20	b	11 L-O	Calc. fr (10 L-O & Fn 19,20)
3 I	6g	6 P-R	Calc. fr (5 P-R)	11 PQR	Calc. fr (4 PQR minus 7 PQR)
3 JK	g	7 BC & Fn 22	2	Fn 6	4c
3 L & Fn 12	b	7 HI & Fn 23	7g	Headnote	d
3 MNO & Fn 13	17,18	7 L	4c [12-16]i		
3 P R & Fn 14	10j,11j	7 P	a		
3 Q	Calc. by b & e fr 10,11,19	8 BC HI L P	Calc. fr (4 and 7 BC HI L P)		
4 B-G	1f,8f				
4 HI	Calc. fr (1 HI-3 HI) by g				

Contributors: (a) Bird, H. R. (b) Comba, G. F. (c) Hibbs, J. W., and Conrad, H. R. (d) Howe, P. E. (e) Irvin, H. M. (f) Maynard, L. A. (g) Rinehart, J. F., and Greenberg, L. D. (h) Swanson, E. W. (i) Tillman, A. D. (j) Tomhave, A. E., and Mellen, W. J.

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82. ACCUMULATIVE EFFICIENCY OF FEED UTILIZATION FOR GROWTH: VERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 B-G I	4e,5e	5 B D F	7	9 B-G	a
3 B-G	4e,5e	6 B-G & Fn 1,2,3	1b	10 B-I	a
4 B D F	6	7,8 B-G I	a	Fn 2,3,4	Calc. fr c

Contributors: (a) Bird, H. R. (b) Davey, R. (c) Johnson, E. L. (d) Mills, C. A. (e) Swanson, E. W.

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83. ABSORPTION, RETENTION, EXCRETION OF NORMAL TISSUE CARTIONOGENS: MAMMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 D F IJ	15a,16a	7 B FG I K	6a,7a,16a	13 DE G I	1a
2 C E G IJK	11a,14a,18a 19a,20a	8 C EFG IJ	15a,16a,18a	14 B EFG IJK	9a,15a,16a
3 B FG IJK	8a,16a,21a	9 D-G JK	5a,9a,12a,16a,23a	15 C FG I K	9a,16a,18a
4 C F IJK	3a,9a,16a,18a 22a	10 C FG I	2a,7a,9a,16a,18a	16 D F	16a
5 C F IJ	16a,18a	11 B G IJK	4a,15a,24a	17 D FG IJK	12a,16a,17a,18a
6 D F K	9a,10a,11a,18a	12 B FG IJ	13a,25a		

Contributor: (a) McChesney, E. W.

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84. ABSORPTION, RETENTION, EXCRETION OF FOREIGN CATIONOGENS: MAMMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 D-G I K	29a	15 DEF I	2a,8a,10a,39a	28 C EF I K	6a,21a,31a
2 C E-I K	5a,6a,10a	16 C EFG IJK	7a,10a,24a,32a	29 C I K	20a
3 C FG I K	10a,13a,15a,32a	17 C FG IJK	32a	30 D G	8a
4 C E I K	8a,10a,19a,32a	18 DE G K	9a,10a	31 D F	10a
5 D-G I K	25a,32a,36a,37a	19 DE	8a	32 B F-I	16a,17a,32a
6 D-G I K	10a,14a,32a	20 D G I	2a,8a	33 D-G IJ	10a,30a,32a,34a
7 D F I K	10a,21a,34a,38a	21 D-G I K	10a,18a	34 C E I K	8a,21a
8 DEF K	8a,32a	22 DF I K	10a	35 C F HIJ	8a,32a
9 DEF I	35a	23 D-G I K	1a,8a,23a,27a,33a, 40a	36 B FG I K	32a,42a,43a
10 D-G I K	28a			37 DEF I K	8a,26a,44a
11 B G I	22a	24 D-G I K	11a,31a,41a	38 C EF I	3a,32a
12 DEF I K	4a,12a,32a	25 DEF K	8a,10a	39 DEF I K	2a,8a,23a,33n
13 B EFG I K	32a	26 DEF K	8a	40 DE	2a,8a
14 D F I K	32a	27 DE	29a		

Contributor: (a) McChesney, E. W.

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85. ABSORPTION, RETENTION, EXCRETION OF NORMAL TISSUE ANIONOGENS: MAMMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B EFG I-L	8a	3 B E J	7a,8a,10b	6 C EFG JKL	8a
2 B EFG JKL	7a,8a	4 B FG JK	8a	7 C F J L	3a,4a,6a,7a
2-4 H	ac	5 C EF JL	2a,4a,5a,9a	8 B F J L	1a,5a,8a

Contributors: (a) McChesney, E. W. (b) Smith, F. A. (c) Walker, B. S.

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86. ABSORPTION, RETENTION, EXCRETION OF FOREIGN ANIONOGENS: MAMMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B FG IJK	3a	3 B G IJK	3a	5 B FG IJK	3a
1,5 H	4b	4 D F I	2a	6 C EF I	1a,3a
2 B F I K	1a,3a				

Contributor: (a) McChesney, E. W. (b) Walker, B. S.

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87. CHEMICAL ELEMENTS, FUNCTIONS: ANIMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-4 B	1a,2a	74-84 B	14a,15a	119-121 E	4a,21a
1-9 C	1a,2a	74-82 C	14a,15a	137-144 B	5a,6a,22a
1,2 E	3a	74-76 D	14a,15a	137-140 C	5a,6a,22a
10-17 B	4a	74,75 E	14a,15a	137,138 D	5a,6a,22a
10-20 C	4a	85-90 B	16a	137-143 E	5a,6a,22a
10-16 D	4a	85-87 C	16a	145-152 B	23a
10-13 E	4a	88-90 C	17a	145-149 C	24a
21 B	5a,6a	85-88 D	16a	145-147 D	23a
21-29 C	5a,6a	89-91 D	18a	145-148 E	23a
21-27 D	5a,6a	85-99 E	16a	153-165 B	5a,6a
21-25 E	5a,6a	100-105 B	4a	153-161 CD	5a,6a
30-32 B	7a	100-103 C	4a	153-160 E	5a,6a
30-33 C	7a	100-102 D	4a	166-170 BC	25a
30-37 D	8a	103-105 D	9a	166-174 D	25a
38,39 D	9a	100,101 E	4a	166-171 E	25a
30,31 E	7a	106-110 B	19a	175,176 B	26a
40-44 B	10a	106-112 C	19a	175-177 C	26a
40-54 C	11a	106-109 D	9a	175-178 D	26a
40-69 D	10a	110-118 D	20a	175,176 E	27a
40-57 E	10a	106-109 E	19a	179-183 BC	28a
70-73 B D	12a	119-126 B	4a,21a	179-186 D	28a
70-73 C	13a	119-136 C	4a,21a	179,180 E	28a
70,71 E	12a	119-131 D	4a,21a		

Contributors: (a) Free, A. H., and Crandall, L. A., Jr.

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88. TRACE ELEMENTS, FUNCTION: ANIMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B	10a,114b	16-18 G	20d	57-63 E	67a
2,3 B	14b	19-21 G	21d	64-69 E	69ad
1,2 C	11a,14c,d	29,30 C	40a	50-53 F	70a
3-6 C	3a,14c	31-34 C	39d,41d,43d	54-56 F	78a
7,8 C	12a,14c	29-38 E	37a,38a,42a,45a, 46a,47a,48a,49a	50,51 G	66a
1-4 D	8a,14c			52-55 G	67d
5-7 D	6e,7a,14c	39 E	50a	70-74 C	92a
8-10 D	1a,5a,14c	29-32 F	51a	75-76 C	91a
1-4 E	2a,9a,13a,14c	29-31 G	44a	77,78 C	81a
5 E	4a,14c	32-35 G	40ae	79-81 C	87a,88e
6-8 E	14c	40 B	62a	82,83 C	85a,86e
1-3 F	5a,14c	41 B	60a	84,85 C	94a
1-3 G	4a,14c	42 B	54b,57b	86-88 C	80a
11 B	25a,14c	43 B	57a,61a	70-83 D	82a,84a,89a,93a,95a
12 B	29e,14c	44 B	59a,61b,116b	70-76 E	79a
13,14 B	23a,14c	45,46 B	115b,116b	77 E	83ae
15,16 B	36a,14c	41-46 B	63a	70,71 F	90e
17 B	29e,14c	47-49 C	56a	89 B	101a
18 B	14c,24a	41-44 D	63a,64a	90 B	110a
11-13 C	33a,14c	41,42 E	63a	91,92 B	111a
14-16 C	22a,30a,32a,14c	43-49 E	55a	93 B	112a
17,18 C	27a,28a,14c	41-43 F	52a	94 B	102a
19 C	15a,14c	44-46 F	53e	96 B	113e
20 C	34a,14c	50 B	71a,72a	89-103 C	99a,103a,104a
11-16 D	18a,14c	51 B	75a	104-106 C	112a
17,18 D	14c	52 B	a	107,108 C	100a
19 D	18a,19a,14c	53,54 B	73a	89-92 D	96a
20,21 D	19a,14c	55 B	77a	93 D	106a
22-25 D	18a,14c	56 B	68a	94,95 D	97a
26-28 D	35a,14c	57 B	65ae	96-101 D	109a
11-15 E	31a,14c	50,51 C	76a	89,90 E	98d
11,12 F	17a,14c	52 C	74a	91 E	105a
13,14 F	16a,14c	53,54 C	77a	89,90 F	107a
15-21 F	14c	50-59 D	70a	89,90 G	108a
11-15 G	14c	50-56 E	66a		

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Vitamin and Column	References
Vitamin A	
Col. A & Hn	1,11,13,14,17,19 20,27,34,37,39,43, 44,47,49,53,56,61, 67,68,73,74,78,83, 84,86,90,92,93
Col. B	21,30,50,69,72
Col. C	21,50
Ascorbic acid	
Col. A & Hn	21,30,31,33,40,50, 58,64,68,72
Col. B	31,33,40,58,64,68
Col. C	64,68
Biotin	
Col. A & Hn	30,51,68,72,87
Col. B	3,21,30,68,72
Choline	
Col. A & Hn	5,12,31,28,30,37, 68,72,87;and coa-tributed by c,e,m, o,r,s,t,w
Col. B	7,22,30,68,72,92
Col. C	21,30,72
Cobalamin	
Col. A & Hn	3,13,21,30,50,66, 72
Col. B	21,30,50,66,72
Col. C	21,50
Vitamin D	
Col. A & Hn	3,21,30,68,72,and contributed by h,k, o,u
Vitamin D (concluded)	
Col. B	3,21,30,50,68,72
Col. C	3
Vitamin E	
Col. A & Hn	3,4,9,21,30,38,68 72
Col. B	3,4,21,30,38,68,72
Folic acid	
Col. A & Hn	3,6,13,21,30,45,66 72,87
Col. B	3,21,30,45,50,66, 68,72,87
Col. C	66,87
Inositol	
Col. A & Hn	30,85,87
Col. B	21,37,50,68,72
Para-aminobenzoic acid	
Col. A & Hn	13
Vitamin K	
Col. A & Hn	2,3,16,24,25,26,30, 60,68,72
Col. B	2,3,16,24,25,26,60
Col. C	16,68
Niacin	
Col. A & Hn	12,21,29,30,41,50, 68,70,72
Col. B	13,21,30,33,41,50, 68
Niacin (concluded)	
Col. C	30,41
Pantothenic acid	
Col. A & Hn	3,52,68,72
Col. B	13,21,30,50,66,68
Col. C	66
Pyridoxine	
Col. A & Hn	6,8,10,18,'5,55, 57,59,62,65,71, 75,76,77,80,81 88,89,91
Col. B	3,21,30,62,66,68, 72
Col. C	66
Riboflavine	
Col. A & Hn	13,21,30,37,68,72
Col. B	21,30,37,68,72,76 77,79,92, and coa-tributed hy h,k,n, u
Col. C	50,68,79
Thiamine	
Col. A & Hn	21,30,37,54,62,68 72
Col. B	21,30,33,37,68,72
Col. C	36,50
Essential fatty acids	
Col. A & Hn	3,15,35,37,68,72
Col. B	15,35,37,48,50 68,72
Col. C	50

Contributors: (a) Bean, W. B. (b) Bird, O. D. (c) Briggs, G. M. (d) Cheldelin, V. H. (e) Chernick, S. S. (f) Darby, W. J. (g) Emerson, G. A. (h) Hagman, N. C. (i) Harris, P. K. (j) Jolliffe, N. (k) Jones, A. K. (l) Lecoq, R. (m) McDaniel, E. B. (n) Mayer, J. (o) Mickelsen, O. (p) Mitchell, H. K. (q) Morgan, A. F. (r) Reid, M. E. (s) Schwarz, K. (t) Scow, R. O. (u) Silides, D. J. (v) Snell, E. E. (w) Spivey, M. R. (x) Sydenstricker, V. P. (y) Wintrobe, M. M. (z) Youmans, J. B.

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Reviewers: The panel of contributors for this table also served as reviewers.

90. NUTRIENT DEFICIENCY EFFECTS ON REPRODUCTION: MAMMALS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 A & Fn 2	22a,30a,67a,78a, 96a,107a,120a	4 I NOP	70a,71a,101a,109a, 152b	11 J OPQ & Fn 3	85a,87b
1 B	78a	4 J	128b	12 BC GH	16a,19a,118a
1 C	51a,69a,82a,95a, 105a,108a	4 K	70a,111a,b	12 F	16b,118b
1 EF	50a,55a,110a,126a	4 L	70a,111a	12 M	116a,117a
1 GH	11a,22a,31a,32a, 33a,50a,58a,62a, 67a,83a,91a,96a, 100a,107a,120a	4 M	43a,44a,45a,79a, 119a,121a,136b, 151b	12 P	118a,b
				13 A & Fn 2	22a,31a,32a,67a,78a
				13 BC	78a
				13 GH	18a,22a,31a,32a, 92a,104a
		5 BC E	65a,88a,129b		
		5 GH	129b	13 L NOPQ	135b
1 J L N P	5a,6a,50a,52a,55a	5 OPQ	54a,146b	14 G	8a
1 O	6a	6 BC GH	23a,24a,46a,57a	14 N Q	8b
1 A & Fn 2	37b,98a	6 N-Q	25a,57b,150b	15 M	7a,26a
2 B	98a	7 A & Fn 3	72a,73b	16 MN	63a
2 A & Fn 3	41a,97b,98a	7 CDE	68a,69a,137b,140b	17 C E	12a,89a,103a
2 GH J L NOP & Fn 3	4ab,17a,31ab,32ab, 41ab,61b,93ab, 97b,98a	7 M	130b,138b	17 FG J	12b,53a,106a,115a
		7 OP & Fn 7	139b,140b,144b	17 L	21b,102b
		8 M	38a,84a,112a,141b, 143b,149b	17 N	21a,102b
				18 FG L	27a
2 Q	99b	8 N	84b	18 N	a
3 A & Fn 2	40a,127b	8 OP & Fn 3	84b,86a,112a,113a	19 EF J	59b,155b
3 B D	14a,35b,40a	8 Q	131a,156b,157b	20 EF J	90a,142b
3 F	14a,127b	9 NO	132b	21 C E	47a,48a,49a,102a
3 K N	13a,34a,56a,60a, 64a,71a,94a	9 P	80a	22 C	76a
		10 A & Fn 2	36a	Fn 12	75a
3 Q	94a	10 BC E	20a,29a	23 BC & Fn 13	74a,153b,154b
4 B	39a,56a,66a,77a, 81a,122a,123a, 124a	10 GH	29a,36a,125a	24 CD	1a,2a,3a,98a
		10 J OP & Fn 3	133b	24 OP	3b
		10 M	9a,10a	Fn 13	154b
4 DE	42a,68a,69a, 114a,123a,124a	11 BC E	28a,134b	Fn 4	135b,145b,147b,148b
		11 GH	29a		

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91. FUNCTIONS OF ESSENTIAL ELEMENTS: HIGHER PLANTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 BC	4b,6b,7b,8b	21,22 BC	4b,5b,6b,7b,8b,11b	43,44 C	4b,5b,6b,7b,8b
3,4 C	4b,5b,6b,7b,8b	23 BC	4b,5b,6b,7b,8b,a	46 BC	4b,5b,6b,7b,8b,9b
3,5 C	1b	24,25,28,31-33 BC	4b,5b,6b,7b,8b,11b	47-52 BC	4b,5b,6b,7b,8b,9b,a
6,7 BC	4b,5b,6b,7b,8b,a	26,27 BC	4b,5b,6b,7b,8b, 11b,a	53,54 C	4b,6b,7b,8b
8-10 BC	4b,5b,6b,7b,8b			55,56 C	4b,5b,6b,7b,8b,a
11-13 BC	4b,5b,6b,7b,8b, 10b,11b	29,30 BC	4b,5b,6b,7b,8b	57-59 BC	4b,5b,6b,7b,8b
		34 BC	4b,6b,7b,8b,11b,a	60,61 BC	4b,6b,7b,8b,a
14 B	4b,6b,7b,8b	35,36 BC	2b,6b,7b	62,63	3b,6b,7b,8b,11b
15-17 BC	4b,5b,6b,7b,8b	37-39 BC	4b,5b,6b,7b,8b,a	Fn 1,3,4,5	b
18-20 BC	4b,5b,6b,7b,8b, 11b,a	40 C	8,c		
		41 B	4b,5b,6b,7b,8b		

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92. SIGNS OF CHEMICAL ELEMENT DEFICIENCY AND EXCESS: HIGHER PLANTS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B	1a,2a,3a,4a,5a,b,i	5 B	1a,2a,3a,4a,5a,e	9 B	1a,2a,3a,4a,5a,b
1 C	1a,2a,3a,4a,5a,e,h	5 C	e	Fn 2	1f
2 B	1a,2a,3a,4a,5a,c	6 B	1a,2a,3a,4a,5a	9 C	a,h
2 C	1a,2a,3a,4a,5a,e	6 C	1a,2a,3a,4a,5a,b	10 B	1a,2a,3a,4a,5a,b
Fn 1	a	7 B	1a,2a,3a,4a,5a	10 C	1a,2a,3a,4a,5a
3 B	1a,2a,3a,4a,5a	7 C	11g	11 BC	1a,2a,3a,4a,5a
3 C	7g,8g,9g,10g,b,e	8 B	1ad,2a,3a,4a,5a,b,e	12 B	1a,2a,3a,4a,5a,12i
4 BC	1a,2a,3a,4a,5a	8 C	1a,2a,3a,4a,5a,c	12 C	6f,7g,9g,10g
				Fn 3	1

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B	9,56b,j	5 B	e	9 B	18a,i
1 C	3,18b,a	5 C	18,54	9 C	18,54
1 D	8,54,58a,g	5 D	18,54,a	9 D	54
1 E	18d,48h,54d	5 E	18h	9 E	18dh,54d,68h
1 F	18,37,42,43	5 F	17,18,23	9 F	18b,54
1 G	18,27,a	5 G	55	9 G	55,c,g
1 H	18d,29,31,32,33,35, 47,54d,a,e	5 H	18d,28,30,31,33,35, 54d	9 H	18d,25,31,33,36, 38,54d
1 I	14,18,20,21,41,a	5 I	14,18,54,69c	9 I	14,18,26
2 C	18,55,a	6 B	60af	10 B	12,i,j
2 D	50,54,a	6 C	54	10 C	18,52,53,54
2 E	18dh,54d	6 D	61a,65f	10 D	50,g
2 F	18	6 E	18dh,54d	10 E	18dh,54d
2 G	55,59a	6 F	63a,f,i	10 F	10k,12,18,54
2 H	18d,28,30,31,33,54d	6 G	55	10 G	55
2 I	18,39,55	6 H	18d,33,35,47,54d	10 H	1,12,18d,28,31,33, 34,36,54d,e
3 B	44	6 I	18,46		
3 C	11	7 B	13h	10 I	12,14,18,22,40
3 D	15	7 D	62a	11 B	45,j
3 E	7,18dh,54d,a	7 E	67h	11 C	i
3 F	70c	7 G; H	64a; 71e,72e	11 D	e
3 G	15,18,a	7 I	2h	11 E	18h
3 H	18,35,e	8 B	19	11 F	f,i
3 I	18,49	8 C	18,52,53,54	11 H	18,31,33,e
4 B	18,j	8 D	54	11 I	14,18
4 C	54	8 E	18h	12 B	66f
4 D	e	8 F	18b,i,j	12 C	18
4 E	18h	8 G	55,c	12 E	18dh,54d
4 F	41	8 H	16,18d,25,31,33,36, 54d,e	12 F	4,5,6,57b,f
4 H	18,31,35			12 H	18d,35,54d
4 I	18	8 I	14,18,24	12 I	18

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94. CORRELATION BETWEEN SOIL pH AND SIGNS OF CHEMICAL ELEMENT DEFICIENCY

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1	d	16,17 BC	17d	29,30 D	6d
1 BC E & Fn 3	1d	Fn 6	b	29-31 E	5d,6d,19d
2 BC	2d	16-18 D	6d,18d	32 BC	c
2-6 DE	2d,3d,4d,5d,6d	16-18 E	5d,6d,19d	32,33 D	6d
7 BC; Fn 4	7d;8d	19 B;19-21 CD	c;6d,9d	32-34 E	5d,6d,14d
Fn 5	a	19 E	5d,6d,7d,14d,20d	35 BC	c
7 D	6d,c	22,23 BCD	21d	35 DE	6d,26d
7,8 E	6d,9d,c	22,23 E	5d,6d,15d,21d	Fn 7	d
9,10 DE	4,10	24 BC	22d	36 B;36-38 CDE	c;6d,19d,27d
11 BC	c	24 D	22d,23d	39 B	c
11,12 D	11d,12d	24-26 E	4d,5d,23d,24d	39,40 CD	28d
11-13 E	4d,6d,11d,13d, 14d,15d	27 B;27,28 CD	c;6d	39-42 E	3d,5d,6d,12d,13d, 15d,28d,29d
		27,28 E	5d,6d,23d		
14,15 CDE	4d,16d	29,30 BC	25d		

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95. CORRELATION BETWEEN SOIL pH AND SIGNS OF CHEMICAL ELEMENT EXCESS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Fn 1	c	10 DE	15c,16c	16 E & Fn 4	12c,13c,14c
1 BC	1c	11 B-E	4c,8c,9c	18 B	b
1,2 DE	2c,3c	12 B;12 DE	d;4c,10c	18,19 D	16c,17c
3,4 CDE	4c,5c	13 BC	1c	18,19 E	15c,17bc
Fn 3	a	13-15 DE	3c,11c,d	20-23 DE	18c,19c
5 B;5,6 DE	d;6c,7c	16 BC	12c,13c	24 B	c
7,10 B	c	16,17 D	13c	24 DE	15c,16c,20c
7-9 DE	15c,16c				

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96. FUNCTIONS OF ESSENTIAL ELEMENTS: BACTERIA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BC	1a	30 BC	19a	56 BC	34a
2 BC	2a	31 BC	20a	57 BC	35a
4 BC	3a	32 BC	21a	58 BC	36a
7 BC	4a,5a	33 BC	22a	60 BC	15a
9 BC	6a	35 BC	1a	62 BC	31a
10 BC	7a	36 BC	23a	63 BC	37a
12 BC	8a	37 BC	24a	64 BC	38a
14 BC	9a	38 BC	25a	65 BC	39a
15 BC	10a	39 BC	1a	66 BC	40a
16 BC	11a	40 BC	26a	68,72 BC	41a
17 BC	12a	41 BC	27a	74 BC	42a
19 BC	13a	42 BC	28a	76 BC	43a
21 BC	14a	43 BC	29a	78,80 BC	44a
22 BC	15a	44,46 BC	30a	82 BC	45a
23 BC	16a	48 BC	31a	85,87 BC	46a
24 BC	17a	49 BC	17a	89 BC	47a
25 BC	18a	50 BC	32a	91,93 BC	48a
27 BC	19a	52 BC	33a	94,96 BC	49a
28 BC	18a	54 BC	4a	97 BC	50a

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97. CHEMICAL CHANGES IN PROTEIN DIGESTION AND ABSORPTION: MAMMALS

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References: A large number of citations to the literature have been supplied by contributors. These are on file in the Handbook Office and, at the time of going to press, are in process of tabulation.

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98. CHEMICAL CHANGES IN CARBOHYDRATE DIGESTION AND ABSORPTION: MAMMALS

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99. CHEMICAL CHANGES IN LIPID DIGESTION AND ABSORPTION: MAMMALS

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References: A large number of citations to the literature have been supplied by contributors. These are on file in the Handbook Office and, at the time of going to press, are in process of tabulation.

Reviewers: Davenport, H. W.; Frazer, A. C.; Hollander, F.; Ivy, A. C.; Kleiner, I. S.; Ravdin, I. S.; Sobotka, H.; Vars, H. M.

100. PATHWAYS OF AMINO ACID METABOLISM

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101. PATHWAYS OF PURINE AND PYRIMIDINE NUCLEOTIDE METABOLISM

Reactions and Footnotes	References	Reactions and Footnotes	References	Reactions and Footnotes	References
Nucleotides —A→		Guanosine —H→		Urea —O→ CO_2 +	
Nucleosides	19,29,32,42,43, 48,51,54	Xanthosine	17,26,32,50	NH_3	28
Adenylic Acid —B→		Guanine —I→		Uracil —8→	
Inosinic Acid	11,46,52	Xanthine	15,16,17,30,33,43, 50	β-alanine	56,57
Adenosine —C→		Pyrimidine nucleo-		Footnotes 1,2,3,4	General References
Inosine	8,11,17,32,46,55	sides —J→		Footnote 5	10
Adenine —D→		Bases	13,38	Footnote 6	28,56,57,58
Hypoxanthine	5,15,16,18	Cytidine —K→		Footnote 7	28
Purine Nucleo-		Uridine	47,53	Footnote 8	56,57
sides —E→ Bases	20,21,22,23,24,34, 36,37,39,43,49	Cytosine —L→		Footnote 9	1,2,3,4,6,7,12,14, 25,31,35,40,43, 45,47, and General Refer- ences
Hypoxanthine —F→		Uracil	10,27,41		
Xanthine	1,3,4,6,7,12,14, 25,31,35,40,43, 45	Uracil —M→			
		Barbituric Acid	28		
		Barbituric		Footnote 10	2
Guanylic Acid —G→		Acid —N→			
Xanthylic Acid	47	Malonic Acid +			
		Urea	28		

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102. PATHWAYS OF NUCLEOPROTEIN CATABOLISM

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103. PATHWAYS OF CARBOHYDRATE METABOLISM: GLYCOLYSIS

Diagram adapted from diagrams contributed by: (a) Bishop, D. W. (b) Bonner, J. F. (c) Kaplan, N. O. (d) Roe, J. H., (e) Thurlow, J. (f) Wainio, W. W. (g) Weinstein, J. J., (h) Werkman, C. H., and based on: (1) Baldwin, E., Dynamic Aspects of Biochemistry, Cambridge Univ. Press. (2) Dickens, F., in Sumner and Myrback,, The Enzymes; Chemistry and Mechanism of Action, 2:624. (3) Lardy, H., Respiratory Enzymes, Minneapolis: Burgess Publishing Co., 1949. (4) Krebs, H. A., Adv. Enzymology, 3:191, 1949. (5) Sumner, J. B., and Sommers, G. F., Chemistry and Methods of Enzymes, New York: Academic Press Inc., 1947. (6) Umbreit, W. W., Metabolic Maps, Minneapolis: Burgess Publishing Co., 1952. (7) West, E. S., and Todd, W. R., Textbook of Biochemistry, New York: The Macmillan Co., 1951. (8) Werkman, C. H., and Wilson, P. W., Bacterial Physiology, New York: Academic Press, 1951 (chapt. 9). (9) Cori, C. T., etal. Biochim. et Biophys. Acta, 7:304, 1951.

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104. PATHWAYS OF LIPID METABOLISM: MAMMALS

Reactions and Footnotes	Contributors and References	Reactions and Footnotes	Contributors and References	Reactions and Footnotes	Contributors and References
Triglycerides ⟶ Di- and Monoglycerides	1c,12bc,13c,69b	Di- and Monoglycerides ⟶ Glycerol	6c	Phospholipid ⟶ Glycerophosphate	76f,77f,78f,79f,80f
Triglycerides ⟵ Di- and Monoglycerides	2c,3c,4c,5c,76b	Di- and Monoglycerides ⟵ Glycerol	2c,3c,4c,5c	Phospholipid ⟵ Fatty Acid; Modified Fatty Acid	8c,9c,10c,11c
Di- and Monoglycerides ⟶ Fatty Acid; Modified Fatty Acid	6c	Fatty Acid; Modified Fatty Acid ⟶ Cholesteryl Esters	6c,30b,71b	Pyruvate ⟶ Acetyl ~CoA	14c
Di- and Monoglycerides ⟵ Fatty Acid; Modified Fatty Acid	2c,3c,4c,5c,12b,69b	Phospholipid ⟶ Fatty Acid; Modified Fatty Acid	7c	Fatty Acid; Modified Fatty Acid ⟶ Fatty Acid ~CoA	15c,74c
		Phospholipid ⟶ α-, β?- Glycerophosphoryl-choline	7c	Fatty Acid ~CoA ⟵ Acetyl ~CoA	15c,74b
				Fatty Acid ~CoA ⟶ Acetyl ~CoA	16c,74b

(Continued on the next page)

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
Acetyl ~ CoA → Acetoacetate	16c,18c,19c,74b	Pyruvate → Lactate	64c,65c	β-OH Butyrate	54c
Acetyl ~ CoA ← Acetoacetate	17c,74b	Pyruvate ← Lactate	66c	Fn 17	15c
Acetyl ~ CoA → Krebs Cycle	20c,21c	Ketogenic Amino Acid and Glycogenic Amino Acid, Fn 1	46c,47c	Fn 18	43c,81d,82d,83d, 84d
Acetyl ~ CoA → Cholesterol	22c,23c,24c	Triglycerides Fn 3	27c,28c	Fn 19	49c,50c
Acetoacetate →? Cholesterol	25c,26c	Fn 4	68b	Fn 20	51c
Cholesterol → Cholesteryl Esters	29c,30c,31c,32c, 72b	Fn 8	33c	Fn 21	59c
Pyruvate → Krebs Cycle	38c	Fn 9	34c,56b,70be	Fn 22	a
Fatty Acid ~CoA → Fatty Acid; Modified Fatty Acid	49c,50c	Fn 12	35c,36c,37c,73b	Fn 24	44ce,45ce
		Fn 13	42c	Fn 26	55c,56c,57c
		Fn 14	39c	Fn 27	48c,85d,86d,87d, 88d
		Fn 15	40c,41c	Fn 28	58c
		Acetoacetate Fn 16	52c,53c	Fn 34	60c
				Fn 35	61c
				Fn 36	62c,63c

Diagram adapted from data and diagram contributed by Bloor, W. R., and Stadie, W. C., with modifications by reviewers. Pinpoint bibliography does not list all available references for reactions and footnotes in diagram, but only pertinent references contributed by (a) Artom, C. (b) Bloor, W. R. (c) Flock, E. V. (d) Gurin, S. (e) Van Bruggen, J. T. (f) Weinman, E. O.

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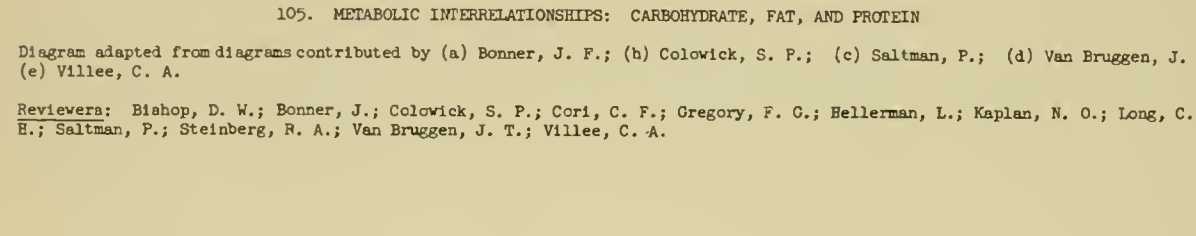
105. METABOLIC INTERRELATIONSHIPS: CARBOHYDRATE, FAT, AND PROTEIN



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106. THE KREBS CYCLE

Reactions and Footnotes	Contributors and References	Reactions and Footnotes	Contributors and References	Reactions and Footnotes	Contributors and References
Aspartate ⇌		Aconitase reaction	6	Fn 5	4
Oxalacetate	1	Oxalsuccinate ⟶		Fn 9	3
Glutamate ⇌		α-Ketoglutarate	7	Fn 11	f
α-Ketoglutarate	1	α-Ketoglutarate ⟶		Fn 17	b
Pyruvate ⟶		Succinate	8	Fn 19	d,f,10
Acetyl CoA	2	Succinate ⟶		Fn 20	f
Oxalacetate +		Fumarate	9		
Acetyl CoA ⟶		Fumarate ⟶			
Citrate	5	Malate	6		

The diagram, in general, has been drawn up from achemata and commenta supplied by all contributors and adapted from general references 11-22.

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107. ACTIVITY METABOLISM: MUSCLE

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108. THE CYTOCHROME SYSTEM: MAMMALS

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109. PATHWAYS OF IRON METABOLISM: MAMMALS

Contributor: Goss, H.

References: Walker, B. S., Boyd, W. C., and Asimov, I., Biochemistry and human metabolism, Baltimore: Williams and Wilkins Co., 1952.

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110. PATHWAYS OF CHLOROPHYLL SYNTHESIS

Contributors: (a) Granick, S. (b) Porter, J. W. (c) Shemin, D.

References: (1) Granick, S., Ann. Rev. Plant Physiol. 2:115, 1951. (2) Shemin, D., and Wittenberg, J., J. Biol. Chem., 192:315, 1951. (3) Shemin, D., and Russell, C. S., J. Am. Chem. Soc. 75:4873, 1953.

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111. THE NITROGEN CYCLE IN NATURE

Reference: Diagram adapted from Bonner, J. F., Plant biochemistry, New York: Academic Press, 1950, contributed by Bonner, J. F.

Reviewers: Bonner, J. F.

Data Coordinates and Footnotes	Contributors and References
1 F J N S	1,1f
1 P	55cg
1 G O Q T & Fn 2	1be
Fn 1 for 1,3 A-T	1bde
2 H-K	1be
3 F H N P S	1be,2,2f
3 J	1
Fn 2 for 3 A-T	1be
4 D F N P	1be,3,3f
4 J	3
4 S & Fn 2	1be
Fn 1 for 4 A-T	1bde
5 H-K	1be
6 D F H J N P S	2
Fn 1 for 6 A-T	2d
7 E G I O Q T & Fn 1,4,5	1bef
8 D F H J N S	2
8 E G O P T & Fn 4	1be
Fn 1 for 8 A-T	1bde
9 H-K	1be
10 G K O Q	4,4f
Fn 1 for 10 A-T	4d
11,12 G H-K OP & Fn 1,2,6,7	4be
13,14 G H-K O Q & Fn 1,2,8	4be
15 F J N S	5
15 G O T & Fn 2	5be
Fn 1 for 15 A-T	5bde
16 H-K	5be
17 B D F L N P S & Fn 2	3bef
17,19 H J	3
17 S & Fn 2	3be
Fn 1 for 17,19 A-T	3bde
18,20 H-K	3be
19 B D F L N P & Fn 2	3bef
21 B D F H J N P	2
21 E G O & Fn 2	1be
Fn 1 for 21 A-T	1bde
22 H-K	1be
23 G I O Q & Fn 11	6,6f
Fn 1 for 23 A-T	6d
24,25 G H-K O & Fn 1,10,11,12	6be
26,28 B D F L N P S & Fn 1,2	6bef
26,28 H J	6
27,29 H-K	6be
30 G O Q T & Fn 1, 10	7be
30 J P	7
31 H-K	7be
32 F-K N-Q ST & Fn 1,10	7be
33 F N P S & Fn 1,13	8bef
34 D F J L O Q	8,9,8f,9f
34 G N P S & Fn 2	8be
Fn 1 for 34 A-T	8bde
35 G-K O Q T & Fn 1,2	9be
36 G N P S & Fn 1,2	8be
37 F P	8bef
37,38 S & Fn 1,13	8be
38 F N P	8bef
39 G O Q	10,11,10f,11f
Fn 1 for 39 A-T	10,11d
40 G O Q T & Fn 1,14	10be
41 B N P & Fn 1,2	12be
42 B P & Fn 1,2	12be
43 P	8,8f
44 F P & Fn 1,4	14bef
44 J N S	14,14f
45 D	15,15f
45 F P & Fn 1,2	15bef
46 B D F H-L N P RS & Fn 1,2,53	16be
47 F N P	8,8f
48 B D F L N P RS & Fn 1,2,53	16be
49 F H J N P S	11,11f
Fn 1 for 49 A-T	11d
50 G-K O QR T & Fn 1,15,53	17be
51 C-G N-S & Fn 1,13,54	18be
52 B D-G N-S & Fn 1,2,54	18be
53 C-G N-S & Fn 1,2,54	18be
54,55 B D F N P RS & Fn 1,15,54	18be
56 C-G N-S & Fn 1,4,54	18be
57 N P	8,8f
58,59 C-G N-S & Fn 1,2,54	18be
60 D F N P S	19,19f
60 E G-K O Q T & Fn 15	19be
Fn 1 for 60 A-T	19d
61 G I O Q & Fn 1,15	29bde 11be
62 G O Q S	8,20,21,8f,21f
Fn 1 for 62 A-T	8d
63 F G NOPQ T & Fn 1,14,16	22be
64,65 F N S & Fn 1,14,17,18	23be
66 D F H-K N P & Fn 1,11,14	21be
67 D G O T & Fn 14,19	24be
68 D GH OP S	21,24,21f,24f
69 G-K N P T & Fn 1,11,14	21be
70 D F H-K N S & Fn 1,14	21be
71 E H-K O Q T & Fn 10,11,20	21be
72 F N P	8,8f
73 G-K O Q T	21be
74 D F J N P RS & Fn 55	25,25f
74 E G O Q T & Fn 1,10	25bef
75 H-K	25be
76 D F H-K N S & Fn 1,14	21be
77 F N S	21,21f
Fn 21 for 77 A-T	21d
78 G-K N P T & Fn 1,11,14	21be
79 D F J N P RS & Fn 55	25
79 E G O Q T & Fn 1,10	26be
80 H-K	26be
81 RS & Fn 10,22,55	26be
82 E G-K O Q T & Fn 10,20	21be
83 D F N S & Fn 1,10	24be
84 F H J N P & Fn 23	27,27f
Fn 1 for 84 A-T	27d
85 F H-K N P & Fn 1,14	27be
86 F N	24,24f
87 D G-K O Q T & Fn 10,11,20	21be
88 D H-K N S & Fn 1,11,14	21be
89 D F J N RS	25
89 E G OP T & Fn 10	25be
Fn 1 for 89 A-T	24d
90 H-K	25be
91 D F N S & Fn 10,19	24be
92 E G-K O Q T & Fn 1,11,14	21be
93 F N S & Fn 10,19	24bef
94,95 D F N	24be
94 S & Fn 10	24be
Fn 19 for 94,95 A-T	24bde
Fn 1 for 95 A-T	24bde
96 F N P & Fn 2	28bef
Fn 24 for 96 A-T	28bde
97 F H N P & Fn 25,56	24,29be
Fn 2 for 97 A-T	29be
Fn 24 for 97 A-T	29bde
98 D F H N	30
98 P T & Fn 2	30be
Fn 1 for 98 A-T	30bde
99 D F J N P	31,31f
Fn 24 for 99 A-T	31d
100 E G O Q & Fn 2,24	31be
101-103 B F N P S & Fn 2,24,26,27	32be
104-106 F N P & Fn 28,29	33c
107 F N P	32,33c
Fn 30 for 107 A-T	33c
108,111 D F N P	33c,34
Fn 31 for 108,111 A-T	33c
109,110,112 D F N P & Fn 2,31	34be
113 D F N P	33c
114 F N P	33c
115 F N P S & Fn 2,24	36be
116 N P	8f,33c
117-119 E G M O T & Fn 14,32,33	36be
120,121 E G M T & Fn 32,33	36be
122 E G M O T & Fn 10,32,34	36be
123 D F L N P	20f,33c,37be
123 S	20
123 T & Fn 10	37be
Fn 1 for 123 A-T	37bde
124 F G & Fn 57	38be
124 N P	38
125 D F L N P	20,20f
125 E G M O Q T & Fn 10,19	13,24be
126,127 D F L N P	33c

(Continued on the next page)

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
127 E G M O Q T	13be,20,24be	152 T	39	178,179 E M OP	43
Fn 1 for 127 A-T	13,24bde	153 E F L N P S &		178,179 F & Fn 11,	
Fn 10 for 127 A-T	13,24be	Fn 14,19,36	39be	12	13be,43
128 D F L N P	20	154 F N P S &		180 F N P & Fn 1	8,44
128 E G M O Q S		Fn 14,19,35	39be	181 D F N P S &	
& Fn 14,19	24be	155 D F L N P S &		Fn 10,45	13be
129,130 D F L N		Fn 14,19,36	39be	182 D F L N S	13,20be,43
P S & Fn 11,12	13be,33c	156 D F L N P	13,37be	182 P	43
Fn 14,19 for 129,		156 S & Fn 10,19	37be	Fn 10,19 for 182	
130 A-T	13be	157 D F N P S &		A-T	13,20be
131 E G O Q T &		Fn 10,38	37be	183 D F L N S	37,43
Fn 14,32	36be	158 F & Fn 41	20	183 E G M O T &	
132 E G M Q T &		159,160 F G & Fn		Fn 10,19	13,37bef
Fn 14,32	36be	14,42,43	40be	183 P	13,37be,43
133 E G M T &		161 D-G L-N P ST		184,185 D F N	37,43
Fn 10,32,34	36be	& Fn 10,19	39be	184,185 E G O &	
134,135 E G M Q T		162 F S & Fn 14,		Fn 10,19	13,37be
& Fn 2,32	36be	19,35	39be	184 P T	13,37be,43f
136 D G L N P	36	163 D F L S &		185 M P T	13,37be,43f
136 E G M O Q T		Fn 14,19,36	39be	186 F N	20
& Fn 1,10	13,24be	164 D F N P S &		Fn 19 for 186 A-T	20d
137 D G L N P	8,13,24be	Fn 10,38	37be,43f	187 F N & Fn 14,19	45be,53a,54a
137 S & Fn 10	13,24be	165 D F L N S &		187 P	45,53a,54a
Fn 1 for 137 A-T	13,24bde	Fn 2,11,40	13be	188 F & Fn 14,19	46be
138 D F N P S		166 D F N S &		188 N	46
& Fn 10,19	13,24be	Fn 2,12,40	13be	189 F N P & Fn 46	47,48
139,140 D F L N		167 E-G M OP &		189 F & Fn 14,19	47,48bc
P S & Fn 10,19		Fn 2,12,44	13,20,37be	190 F & Fn 19,47	49
35,36	39be	168 F O & Fn 2,		191 N & Fn 14,19,	
141 D G M O Q T		12,24	41be	58	46be
& Fn 10,19	24be	169 E G L OP ST &		192 F S & Fn 11,	
141 F N P	37	Fn 2,11,44	13,20,37be	14,19	49be
142,143,145 D F L		Fn 2 for 169 A-T	37be	193 F & Fn 14,19,	
N P S & Fn 10,		170 F N & Fn 2,11	41be	48,49	49be
19,37-39	13be	Fn 41 for 170 A-T	13,20d	194 F & Fn 14,50,	
144 F L N S &		171 D P	42	51	49be
Fn 10,19,39	13be	171 F J N & Fn 2	42be	Fn 19 for 194 A-T	49d
146 D F L P Q	39	Fn 1 for 171 A-T	42d	195 F & Fn 14,19	50be
146 N T	39be	172,173 F N & Fn		196 F & Fn 52	46,51d
147 E G L O Q T		2,40,45	42be	196 N	48d
& Fn 2,40	13be	174,175 D G L N P		Fn 19 for 196 A-T	46,51d
148,149 D F L N P		S & Fn 11,12,		197 N & Fn 14,19,	
S & Fn 2,11,12,		14,19	37be	58	46be
40,57	13be	176,177 FG & Fn		198 F & Fn 14	52be
150,151 E G M O Q		14,19,42,43	40be	198 N	52
& Fn 2,11,12,40	37be	178,179 D L N S		Fn 19 for 198 A-T	52bde
152 D F L N P S &		& Fn 14,40	13be		
Fn 14,19,35	39be				

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B	1,2,g,3n,81j	27 B	48,49hj	59 BC	49n
1 C	1n,4,5f,6f,81j	27 C	48,48n,49hj,50n, 54n,57n	60 B	47,50n,64j
1 E	1n,7n,9n			60 C	50n,64j
2 B	2	28 BC	48	61 BC	47n,50n
2 C	1n,4n,5,6	29 B	49j	62 BC	47n,50n
2,3 D	8a	29 C	49j,54c	63 B	48,49hj
2 E	8n,9n	30 B	47n,54hjn,57n	63 C	10n,47n,48,49hjn, 50n,52-57n,64n
3 B & Fn 2	Calc from 7-11 BC See also 1n,2n, 3j,10-16n	30 C	54h	64 BC	48
		32 C	47n,54cjn,57n	65 BC	10n,47n,49-53n, 54cn,55-57n,64n
3,5 C	3j,1n,2n,4n	33 B	48,49hj		
3 EFG	17n	33 C	47n,48,49hj,54n,57n	65 D	59a
4 C	10-16n	34 BC	49	65 E	59n
5 FG	17h	35 BC	49j,54c	65 FG	60bhik
6 BC	Calc.from 12-71 BC	35 D	59a	66 B	48,49hj
6 FG	191k	35 E	59n	66 C	47n,48,49hjn,50n, 53-55n,63n,64n
7 B	1d,2,3j,11j,20m, 21-24d	35 FG	60bhik		
		38 B	47n	67 BC	48
7 C	3j,5f,6,6efno,11n, 25-28n	39 B	48,49hj	68 BC	47,49n,50n,53-55n, 63n,64n
		39 C	47n,48,49hjn,50n, 52n,53n,55-57n,65n		
7 F	291k	40 BC	48	68 FG	60bhik
7 G	291k,31b	41 BC	47n,49n,50n,52n, 53n,54c,55-57n,65n	69 B	48,49j
8 B	1d,2,20m,21-24d			69 C	48,49jkn,50n,57n, 63n
8 C	1n,5f,6f,32	41 D	59a		
9 B	1d,2,3j,21-24d	41 E	59n	70 BC	48
9 C	1,3j,5f,6f,33n, 34n	41 FG	60bhik	71 B	49j
		42 B	48,49hj	71 C	49j,54c
9 FG	351k,361k,81n	42 C	10n,48,49hjn,50n, 52n,53n,55-57n,65n	71 FG	60bhik
10 B	1dn,2,6,20m,21-24d			72 B	48,49hj
10 C	1,1n,37-39n	43 BC	48	72 C	10n,48,49hjn,50n, 52-57n
10 F	40h	44 B	49j		
10 G	40bh	44 C	10n,49jn,50n,52n, 53n,54c,55-57n,65n	73 BC	48
11 B	1d,2,3j,20m,21-24d			74 B	49j
11 C	1d,3j,5f,6f,11n, 41,41-43n	44 D	59a	74 C	10n,49jn,52n,53n, 54cn,55-57n
		44 E	59n		
11 E	44n	44 FG	60bhik	74 D	59a
11 G	451k,461k	45 B	48,49hj	74 E	59n
14 B	47n	45 C	10n,47n,48,49hn, 50-57n	74 FG	60bhik
15 B	48,49hj			75 C	47n
15 C	47n,48,49hjn,50-58n	46 BC	48	76 B	2,21-24d
16 BC	48	47 BC	10n,47n,49n,50-53n, 54cn,55-57n	76 C	1d,5f,32,67n
17 C	47n,49n,50-53n, 54cjn,55-57n			77 BC	68eo,69eo
		47 D	59a	78 C	62n
17 D	59a	47 E	59n	79 B	2,20m,21-24d, 70gn,71j
17 E	59n	47 FG	60bhik		
17 FG	60bhik	48,49 B	48,49hj	79 C	1d,5f,70,70n,71j 72n,73n
18 B	48,48n,49hj	48 C	10n,47n,48,49hjn, 52-57n,65n,66n		
18 C	47n,48,49hjn,50n, 54n,55n			80 B	68eo,69eo
		50 BC	48,49hj	81 B	2,21-24d,74j
19 BC	49	51 B	47n	81 C	1d,2n,5f,74j
20 BC	47n,49n,50n,54n, 57n	54 B	48,49gh	81 E	75n
		54 C	47n,48,49ghn,50n, 53-55n,57n,63n	82 C	26n
21 BC & Fn 5	61j,n			83 C	76n,77n
23 C	62n	55,58 BC	48	84 BC & Fn 7	11j
24 B	48,49dj,57n, 63n	56 BC	47n,49n,50n,53-55n, 57a,63n	85 C	69eo
				86 B	1
24 C	48,49hj	56 FG	60bhik	86 C	1,78n,79n
26 C	49n,63n,64n	57 B	48,49hjn	86 E	80n
		57 C	48,49hj		

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 D	1b,2d	4 DE	2d,4b	7 DE & Fn 5	8bd
1 E	1b,2d	5 DE	2d	7-10 H & Fn 6	6ac
2 DE	2d	5 H	5c	11 DE	3bd
3 DE & Fn 3	3bd	6 H & Fn 4	6ac	12-14 H & Fn 7	6ac
		7 C	7		

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 C	1	9 G	19b	15 C	40j,41hj
2 B	1-5c,6h	10 C	17j,30-33j	15 FG	40bj
2 C	6b,7,8d,9d,10j	10 D	17a	16 BC	41h
2 D	11a	10 E	17aj	17 B	41h,42j
2 E	11a,12j	10 G	34b	17 C	40j,41hj,42j,43j
2 G & Fn 2	13b,14gi	11 B	30h	17 F	40b
3 B	15-17j,18h	11 C	30hj,34ej	18 B	44j,45h
3 C	15,15e,18h	12 B	e,17h	18 C	8d,44,44j,45hj, 46,46-48j
3 D	17a	12 C	17hj,26j,35ej, 36j,37j	18 D	17a
3 E	17aj			18 E	17aj
3 F & Fn 3	19gi	12 D	17a	18 G	14gi,49b
4 E & Fn 4	20j	12 E	17aj	19 B	50b
5 B	21h	12 FG	36bgi	19 C	8d,25j,50,51, 51-54j
5 C	21hj,22j	13 B	17h		
5 G	21bgi,f	13 C	17hj,38j,39j	19 D	17a
6 B	24h,25j	13 D	17a	19 E	17aj
6 C	24h	13 E	17aj	19 FG	49bj
7 DE	26a	13 F	19gi	20 C	32j,33j,55j
8 B	27	13 G	18b	21 C	56j
8 C	17j,24j,27e	14 C	38j	22 C	57j,58j
8 D	17a	14 D	17a	23 C	59-61j
8 E	17aj	14 E	17aj	24 B	62j,63j
8 F	28b	14 F	40gi	25 C	64j
8 G	28gi	14 G	40b		
9 BC	19j,29j	15 B	41h		
9 F	19gi				

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Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B	1-5d	5 F	18a	10 E	33i
1 C	6-12i	6 C	19i,20i	10 G	34gh
2 C	1,28e,43e	7 C	47-50i	11 B	35i
2 F	44a	8 B	21i	12 C	36-38i
2 G	44gh	8 F	22gh,23gh	13 C	51i
3 B	1-5d,34i	8 G	22ghi,23ghi	14 C	39,39f,40,40f
3 G	45i	9 B	1-5d	14 D	41i
4 DE	46bi	9 C	24,24-27i	14 E	42i
4 G	46c	10 B	1-5d,24	15 C	28e
5 C	13,13f,14-17i	10 C	28,28e,29,30-32i		

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117. EXCRETION OF ELECTROLYTES AND MINOR MINERALS: MAN

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
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2 C	9m,10,10q,11f, 12f,13-15q	10 C	4q,11f,52gq,53s 54q,55fg,56g	19 D	30qr
				19 G	71h
2 E	16q	10 G	57i,58h	20 BC	72m
2 G	17ko,18ko	11 B	5-8c	21 B	73q
3 BC	19m,q	11 C	4	21 C	74-76q
3 DE	20a	11 D	59a,60a	22 D	1q
4 C	21q,22q	11 E	59a,60aq	23 B	2,2m,4cn,5-8c,25n, 33m,77n
5 B	2,5-8c, 23	11 FG	32bi		
		12 B	1q,4-8c,19m	23 C	2m,4n,11f,12f,25n, 33m,77n,78
5 C	2,2q,4q,10q,11f, 12f,24m,25n,26n, 27q	12 C	1q,4,19m		
		12 D	1q,62a	23 D	30q
		12 E & Fn 7	86a	23 G	38h,39e,85b
5 D	28a	13 B	2,5-8c,25n,64n	24 B	12q,79m
5 E	29q,30qr,84q	13 C	4q,11f,12f,25n,30q, 63m,64nq,65q,66q	24 C	2q,179m,80q,11f
5 FG	31ko,32i			24 D	30qr
6 B	2,2m,5-8c,25n, 33m,34n	13 D	30qr,66aq	24 G	70bko
		13 E	66a	25 B	2q,79m
6 C	2m,4q,10q,11f,12, 12f,30q,33m,34n, 35,35q	13 FG	31ko,50q	25 C	2q,11f,12f,80q
		14 C	1,1q,67q	26 B	12q,79m
		14 E	1q,67q	26 C	2q,79m,80q

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6 E	36a	14 FG	50bq	27 B	2q,79m
6 G	38h,39be,85b	15 CD	68d	27 C	2,2q,79m,80q
7 BC	2,40q	16 B	4	28 C	1,1gq,67q
7 DE	40a	16 CE	67q	28 E	1q,30qr
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8 C	1,1q,41jq,42-46j, 47m,48q,49q	18 B	2,2q	29 C	81m
		18 C	2q,4q,6,30q,69q	29 D	81a
8 D	1q,42a	18 D	30qr,59a	29 E	81a,82dq,83q,84q
8 E	42a	18 E	59a		
8 F	50b	18 FG	70ko		

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Data Coordinates and Footnotes	Contributors and References
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7 BC	67ac,68a,69a
8,9 BC	67ac,68a
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13 C	229e
14 B	229e
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16 B	230c
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22 B	1a
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28 C	230e
29 B	169a
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64 C	63a,64a
65 B & Fn 5	63c,64a,212c
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75 B	53ac
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82 C	106cd
83 B	94a,95ac,96acd, 97a,100d,174d
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85 B	105ad
86 B	80ac,92ac,93ac
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87 BC	91ac,92a
88 B	110acd,111a
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92 B	185d
93 B	99acd,100ad
93 C	99c
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94 C	87a,88a,89a,90a
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98 B	226c
98 C	226c
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100 C	101c
101 B	85a
102 B	98acd
102 C	98cd
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103 C	118c
104 B	112a,173cd
104 C	173d
105 B	225c
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108 B	186d
109 B	116ac
109 C	116ac
109 B	119a
110 B	117a,118ac
110 C	118c
111 B	119a
112 BC	108acd,180d
112 C	88a,99acd
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114 B	88ac,99acd,198c
114 C	88a,99acd
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117 C	104cd,111d
118 BC	110acd,111acd 181cd
119 B	105a
120 B	227c
121 B	69ac,83ac,84ac
121 C	84c
122 B	115a
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123 C	96c
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125,126 C	123a,124a,125a, 126a
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136 BC & Fn 14	134ac
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147 BC	148a,149a,150a	153 B	167a,192c	158 B	158a,178d,179d
148 B	153a	153 C	192b	159 BC	166c
149 BC	154a	154 B	158a,178d,179d	160 B	156a,157a
150 B	151a,152a	155 B	159a	161 B	153a
151 B	145ac,146ac,210c	156 B	178d,188d	Fn 1	e

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119. PRODUCTS OF CARBOHYDRATE METABOLISM AS AFFECTED BY CHANGE IN pE: YEASTS AND BACTERIA

Data Coordinates and Footnotes	Contributors and References
1-10 BCDEFG	1a
1-10 HI	2a
1-10 JK	3a

Contributor: (a) Ledingham, G. A.

Referencea: (1) Neish, A. C., and Ledingham, G. A., Canad. J. Res. 27B:694, 1949. (2) Neish, A. C., and Blackwood, A. C., (unpublished) (3) Neish, A. C., and Blackwood, A. C., Canad. J. Technol. 29:123, 1951.

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120. PRODUCTS OF CARBOHYDRATE METABOLISM OF INDUSTRIAL IMPORTANCE: BACTERIA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABCD	1b	3 ABC	a	5 ABCD	a
2 A CD	1b	4 A C	1b	Fn 1,2	a
2 B	a,1b	4 B D	a,1b		

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121. METABOLIC PRODUCTS OF BACTERIA: ANAEROBIC FERMENTATION OF GLUCOSE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
7 B	1b	1-3,9,13,14 F	4b	1,2,4,6,9,11,13, 15 I	6b
1,4,7,9,12 C	2b	3,4,7-9 G	4b	1,2,4,6,10,11 J	7b
1,4,5,8 D	3a	1,2,4,6 H	5b	1,2,4,7-9,13,14 K	8b
1-4,7-9 E	4b				

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Reviewers: Delwiche, E. A.; Sherman, J. M.; Umbreit, W. W.; Werkman, C. H.

122. OXYGEN CONSUMPTION: BLOOD FORMED ELEMENTS, MARROW, SPLEEN, LYMPH NODES, THYMUS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1a	9 ABC	11a	18 ABC	13a,14a,24a
2 ABC	1ab	10 ABC	2a,5a,12a	19,23 ABC	18a
3 ABC	2a	11 ABC	12a	20 ABC	16a,17a
4 ABC	3ac	12 ABC	6a	24 ABC	25a
5 ABC	3a,4a	13,15,21,22 ABC	13a,14a	25 ABC	19a,20a,21a,22a,23a
6 ABC	4a	14 ABC	15a	26 ABC	6ac
7 ABC	5a,6ac	16 ABC	16a	27 ABC	9a,11a
8 ABC	8a,9a,10a	17 ABC	19a	28 ABC	10a

Contributors: (a) Barker, S. B. (b) Jandorf, B. J. (c) Quastel, J. H., and Scholefield, P. G.

References: (1) Warren, C. O., Jr., Am. J. Physiol. 131:176, 1940. (2) Glover, E. C., Daland, G. A., and Schmitz, H. L., Arch. Int. Med. 46:46, 1930. (3) Fleischmann, W., and Kubowitz, F., Biochem. Ztschr. 181:395, 1927. (4) Macleod, J., and Rhoads, C. P., Proc. Soc. Exp. Biol. Med. 41:268, 1939. (5) Fujita, A., Klin. Wchnschr. 7:897, 1928. (6) Fujita, A., Biochem. Ztschr. 197:175, 1928. (7) Folley, S. J., and French, T. H., Biochem. J. 45:270, 1949. (8) Rosenthal, O., and Lasnitzki, A., Biochem. Ztschr. 196:340, 1928. (9) Warburg, O., Posener, K., and Negelein, E., Biochem. Ztschr. 152:309, 1924. (10) Wohlgemuth, J., and Klopstock, E., Biochem. Ztschr. 175:202, 1926. (11) Barker, S. B., and Schwartz, H. S., (unpublished). (12) Endres, G., and Kubowitz, F., Biochem. Ztschr. 191:395, 1927. (13) Ramsay, R., and Warren, C. O., Jr., J. Exp. Physiol. 20:213, 1930. (14) Ibid., 22:49, 1932. (15) Kawashima, Y., J. Biochem. (Tokyo) 4:411, 1925. (16) Negelein, E., Biochem. 158:121, 1925. (17) Schlayer, C., Biochem. Ztschr. 293:94, 1937. (18) Wright, G. P., J. Gen. Physiol. 14:179, 1930. (19) Barker, S. B., and Klitgaard, H. M., Am. J. Physiol. 170:81, 1952. (20) Dickens, G., and Greville, G. D., Biochem. J. 27:832, 1933. (21) Dickens, F., and Simer, F., Biochem. J. 24:1301, 1920. (22) Murphy, J. B., and Hawkins, J. A., J. Gen. Physiol. 8:115, 1925. (23) Weil-Malherbe, H., Biochem. Ztschr. 175:202, 1926. (24) Engelhardt, W. A., Biochem. Ztschr. 251:343, 1932. (25) Edson, N. L., and Leloir, L. F., Biochem. J. 30:2319, 1936.

Reviewers: Barker, S. B., Dickens, F., Jandorf, B. J., Krebs, H. A., MacLeod, J., Quastel, J. H. Scholefield, P. G.

123. OXYGEN CONSUMPTION: EPITHELIUM AND ASSOCIATED TISSUES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1a	7 ABC	4a,5a,6a	13 ABC	10ac
2 ABC	1a,2a	9 ABC	7a	14 ABC	10a
3,6,8 ABC	2a	10 ABC	8b	15 ABC	11a
4 ABC	1ac	11 ABC	9ac	16 ABC	11a,12a
5 ABC	3a	12 ABC	9a		

Contributors: (a) Barker, S. B. (b) Jandorf, B. J. (c) Quastel, J. H., and Scholefield, P. G.

References: (1) Rosenthal, O., and Lasnitzki, A., Biochem. J. 196:340, 1928. (2) Dickens, F., and Weil-Malherbe, H., Biochem. J. 35:7, 1941. (3) Barker, S. B., and Klitgaard, H. M., Am. J. Physiol. 170:81, 1952. (4) Dickens, F., and Simer, F., Biochem. J. 24:1301, 1920. (5) Warburg, O., Posener, K., and Negelein, E., Biochem. Ztschr. 152:309, 1924. (6) Weil-Malherbe, H., Biochem. J. 32:2257, 1938. (7) Bell, W. B., Brooks, J., and Jowett, M., J. Cancer Res. 12:369, 1928. (8) Barron, E. S. G., Meyer, J., and Miller, Z. B., J. Invest. Derm. 11:97, 1948. (9) Wohlgemuth, J., and Klopstock, E., Biochem. Ztschr. 175:202, 1926. (10) Loebell, R. O., Biochem. Ztschr. 161:219, 1925. (11) Adams, P. D., Arch. Derm. Syph. 36:606, 1937. (12) Adams, P. D., J. Biol. Chem. 116:641, 1936.

Reviewers: Barker, S. B.; Dickens, F.; Jandorf, B. J.; Krebs, H. A.; Moore, R. O.; Quastel, J. H.; Scholefield, P. G.

124. OXYGEN CONSUMPTION: GLAND TISSUES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1a	7,9,20 ABC	4a	21 ABC	5a,7ab
2,3,11,12 ABC	1ab	8 ABC	3ab,10b	22,24,25 ABC	8a
4,16-19 ABC	2a	10 ABC	5a	23 ABC	9ab
5 ABC	3ab	13,14 ABC	6a	26 ABC	7a
6 ABC	4ab	15 ABC	7ab	27 ABC	3a,11a

Contributors: (a) Barker, S. B. (b) Quastel, J. H., and Scholefield, P. G.

References: (1) Fujita, A., Biochem. Ztschr. 197:175, 1928. (2) Deutsch, W., and Raper, H. S., J. Physiol. 87:275, 1936. (3) Warburg, O., Posener, K., and Negelein, E., Biochem. Ztschr. 152:309, 1924. (4) Edson, N. L., and Leloir, L. F., Biochem. J. 30:2319, 1936. (5) Barker, S. B., and Schwartz, H. S., (unpublished). (6) Roberts, S., and Rock, M., (unpublished). (7) Rosenthal, O., and Lasnitzki, A., Biochem. Ztschr. 196:340, 1928. (8) Barker, S. B., (unpublished). (9) Sturm, A., Ztschr. exper. Med. 74:555, 1930. (10) Mendel, B., Klin. Woch. 10:118, 1931. (11) Walthard, B., Ztschr. exper. Med. 79:451, 1931.

Reviewers: Barker, S. B.; Dickens, F.; Jandorf, B. J.; Krebs, H. A.; Moore, R. O.; Quastel, J. H.; Scholefield, P. G.

125. OXYGEN CONSUMPTION: LUNG

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2,6,7 ABC	1a	4 ABC	3ab	9 ABC	1a,6ab
3,8 ABC	2a	5 ABC	4a,5ab	10 ABC	4ab

Contributors: (a) Barker, S. B. (b) Quastel, J. H., and Scholefield, P. G.

References: (1) Simon, F. P., Potts, A. M., and Gerard, R. W., J. Biol. Chem. 167:303, 1947. (2) Edson, N. L., and Leloir, L. F., Biochem. J. 30:2319, 1936. (3) Krebs, H. A., in Oppenheimer, C., Handbuch der Biochemie des Menschen und der Tiere, Jena, Germany: Fischer, 1933. (4) Fujita, A., Biochem. Ztschr. 197:175, 1928. (5) Ogata, Y., Jap. J. Med. Sci. Trans. III Biophysics 2:131, 1932. (6) Laser, H., Biochem. Ztschr. 248:9, 1932.

Reviewers: Barker, S. B., Dickens, F., Jandorf, B. J., Krebs, H. A., Quastel, J. H. Scholefield, P. G.

126. OXYGEN CONSUMPTION: LIVER

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2,3 ABC	1a	9 ABC	6ab	15 ABC	14a
4,10,18 ABC	2a	11 ABC	8ab	16 ABC	15a,16a,17a
5 ABC	3ac	12 ABC	9a,10a	17 ABC	8a,9a,13a,16a,17a,
6 ABC	4a	13 ABC	11ac,2a		19a,20a,21a,22a,
7 ABC	5ac	14 ABC	13a		23a,2b
8 ABC	5a				

Contributors: (a) Barker, S. B. (b) Kleiber, M. (c) Quastel, J. H., and Scholefield, P. G.

References: (1) Carroll, M. J., Arch. f. exper. Zellforsch. 22:592, 1939. (2) Kleiber, M., Proc. Soc. Exper. Biol. Med. 48:419, 1941. (3) Krebs, H. A. in Oppenheimer, C., Handbuch der Biochemie des Menschen und der Tiere, Jena, Germany: Fischer, 1933. (4) Edson, N. L., and Leloir, L. R., Biochem. J. 30:2319, 1936. (5) Meier, R., and Tholenes, E., Arch. exper. Path. Pharm. 169:655, 1933. (6) Tanyia, C., Biochem. Ztschr. 189:175, 1927. (7) Deutsch, W., and Raper, H. S., J. Physiol. 87:275, 1936. (8) Ogata, Y., Jap. J. Med. Sci. Trans. III Biophysics 2:131, 1932. (9) Crabtree, H. G., Biochem. J. 23:536, 1928. (10) Laser, H., Biochem. J. 31:1671, 1937. (11) Ebina, T., Tohoku J. Exper. Med. 13:424, 1929. (12) Burk, D., Cold Spring Harbor Symp. Quant. Biol. 7:420, 1939. (13) Rosenthal, O., and Lasnitzki, A., Biochem. Ztschr. 196:340, 1928. (14) Hawkins, J. A., J. Gen. Physiol. 11:645, 1928. (15) Dickens, F., and Greville, G. D., Biochem. J. 27:832, 1933. (16) Meyerhof, O., and Lohmann, K., Biochem. Ztschr. 171:381,421, 1926. (17) Minami, S., Biochem. Ztschr. 142:334, 1923. (18) Barker, S. B., and Klitgaard, H. M., Am. J. Physiol. 170:81, 1952. (19) Dickens, F., and Simer, F., Biochem. J. 24:1301, 1920. (20) Elliott, K. A. C., Greig, M. E., and Benoy, M. P., Biochem. J. 31:1003, 1937. (21) Grassheim, K., Ztschr. klin. Med. 103:380, 1926. (22) Myerhof, O., Lohmann, K., and Meier, R., Biochem. Ztschr. 157:459, 1925. (23) Warburg, O., Posener, K., and Negelein, E., Biochem. Ztschr. 152:309, 1924.

Reviewers: Barker, S. B.; Dickens, F.; Elliott, K. A. C.; Jandorf, B. J.; Kleiber, M.; Krebs, H. A.; MacLeod, J.; Quastel, J. H.; Scholefield, P. G.

127. OXYGEN CONSUMPTION: MISCELLANEOUS TISSUES, COMPARATIVE

Reference: Data contributed by Quastel, J. H., and Scholefield, P. G., and adapted from Krebs, H. A., Biochim. et Biophys. Acta 4:249, 1950.

Reviewers: Barker, S. B.; Dickens, F.; Jandorf, B. J.; Krebs, H. A.; Moore, R. O.; Morrison, P. R.; Quastel, J. H.; Scholefield, P. G.;

128. OXYGEN CONSUMPTION: MISCELLANEOUS TISSUES, IN THE PRESENCE OF VARIOUS SUBSTRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-6,8,14-20,23,		9 ABC	a	Fn 2-4	5a
24 ABC	1ab	10-13,25-27 ABC	3a	Fn 5-7	4a
7 ABC	2a	21,22 ABC	4a		

Contributors: (a) Barker, S. B., (b) Quastel, J. H., and Scholefield, P. G.

References: (1) Jowett, M., and Quastel, J. H., Biochem. J. 31:565, 1937. (2) Laser, H., Biochem. Zschr. 248:9, 1932. (3) Shorr, E., Cold Spring Harbor, Symp. Quant. Biol. 7:323, 1939. (4) Crabtree, H. G., Biochem. J. 23:536, 1928. (5) Meyerhof, O., Lohmann, K., and Meier, R., Biochem. Zschr. 157:459, 1925.

Reviewers: Barker, S. B.; Dickens, F.; Jandorf, B. J.; Krebs, H. A.; Moore, R. O.; Quastel, J. H.; Scholefield, P. G.;

129. OXYGEN CONSUMPTION: MUSCLE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and Refereoces	Data Coordinates and Footnotes	Contributors and References
1,2,8 ABC	1a	10,14 ABC	2a,9a	16 ABC	2a
3 ABC	2a,3a,4a,5a,6a	11 ABC	5a,10a,11a,12a,13a	18 ABC	11ab
4 ABC	6a	12 ABC	10a,12a	21 ABC	15a
5,9,17 ABC	7a	13,20 ABC	3a	22 ABC	14a
6,7 ABC	8a	15,19 ABC	14ab		

Contributors: (a) Barker, S. B. (b) Quastel, J. H., and Scholefield, P. G.

References: (1) Barker, S. B., (unpublished). (2) Barker, S. B., and Klitgaard, H. M., Am. J. Physiol. 170:81, 1952. (3) Edson, N. L., and Leloir, L. F., Biochem. J. 35:7, 1941. (4) Gemmill, C. L., Bull. Johns Hopkins Hosp. 68:329, 1941. (5) Meyerhof, O., Lohmann, K., and Meier, R., Biochem. Ztschr. 157:459, 1925. (6) Takane, R., Biochem. Ztschr. 171:403, 1926. (7) Shorr, E., Cold Spring Harbor, Symp. Quant. Biol. 7:323, 1939. (8) Warburg, O., Posener, K., and Negelein, E., Biochem. Ztschr. 152:309, 1924. (9) Field, J., 2nd, in Potter, V. R., Methods in medical research, Chicago: Year Book Publishers, 1948. (10) Gemmill, C. L., Am. J. Physiol. 112:294, 1935. (11) Meyerhof, O., and Lohmann, K., Biochem. Ztschr. 171:381,421, 1926. (12) Ochoa, S., Biochem. Ztschr. 227:116, 1930. (13) Saslow, G., J. Cell. Compar. Physiol. 10:385, 1937. (14) Rosenthal, O., and Lasnitzki, A., Biochem. Ztschr. 196:340, 1928. (15) Dickens, F., and Weil-Malherbe, H., Biochem. J. 35:7, 1941.

Reviewers: Barker, S. B., Dickens, F., Jandorf, B. J., Krebs, H. A., Quastel, J. H. Scholefield, P. G.

130. OXYGEN CONSUMPTION: NEOPLASMS, BENIGN, AND HYPERPLASTIC TISSUE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1ab,2ab	3,4,5 ABC	3a	8 ABC	4ab
2 ABC	2a	6,7 ABC	1a,4ab	9 ABC	5a

Contributors: (a) Barker, S. B. (b) Quastel, J. H., and Scholefield, P. G.

References: (1) Rosenthal, O., and Lasnitzki, A., Biochem. Ztschr. 196:340, 1928. (2) Walthard, B., Ztschr. exper. Med. 79:451, 1931. (3) Warburg, O., and Kubowitz, F., Biochem. Ztschr. 189:242, 1927. (4) Warburg, O., Posener, K., and Negelein, E., Biochem. Ztschr. 152:309, 1924. (5) Crabtree, H. G., Biochem. J. 22:1289, 1928.

Reviewers: Barker, S. B., Dickens, F., Jandorf, B. J., Krebs, H. A., Quastel, J. H.; Scholefield, P. G.

131. OXYGEN CONSUMPTION: NEOPLASMS, MALIGNANT

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,13 ABC	1a	5,6 ABC	7a	10 ABC	10a,12a,15a
2 ABC	1a,2a,3ab,4a,5a	7 ABC	8a	11 ABC	16a
3 ABC	4a,5a	8 ABC	6ab,9a	12 ABC	4b,6a,9a,17b
4 ABC	6a	9 ABC	6a,11a,12a,13ab,14a		

Contributors; (a) Barker, S. B. (b) Quastel, J. H., and Scholefield, P. G.

References: (1) Murphy, J. B., and Hawkins, J. A., J. Gen. Physiol. 8:115, 1925. (2) Loebell, R. O., Biochem. Ztschr. 161: 219, 1925. (3) Minami, S., Biochem. Ztschr. 142:334, 1923. (4) Rosenthal, O., and Lasnitzki, A., Biochem. Ztschr. 196:340, 1928. (5) Warburg, O., Posener, K., and Negelein, E., Biochem. Ztschr. 189:242, 1927. (6) Crabtree, H. G., Biochem. J. 23: 536, 1928. (7) Glover, E. C., Daland, G. A., and Schmitz, H. L., Arch. Int. Med. 46:46, 1930. (8) Peschel, E., Klin. Wchnschr. 9:1061, 1930. (9) Laser, H., Biochem. J. 31:1671, 1937. (10) Crabtree, H. G., Biochem. J. 22:1289, 1928. (11) Dickens, F., and Greville, G. D., Biochem. J. 27:832, 1933. (12) Dickens, F., and Simer, F., Biochem. J. 24:1301, 1920. (13) Okamota, Y., Biochem. Ztschr. 160:52, 1925. (14) Weil-Malherbe, H., Biocbem. J. 32:2257, 1938. (15) Warburg, O., Biochem. Ztschr. 160:307, 1925. (16) Krebs, H. A., and Kubowitz, F., Biochem. Ztschr. 189:194, 1927. (17) Warburg, O., Biochem. Ztschr. 152: 309, 1924.

Reviewers: Barker, S. B., Dickens, F., Jandorf, B. J., Krebs, H. A., Quastel, J. H.; Scholefield, P. G.

132. OXYGEN CONSUMPTION: NERVE TISSUE, INCLUDING RETINA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 ABC	1a	14,15 ABC	11a	25 ABC	11a,22a
2 ABC	2ab	16 ABC	2a,11a,12a,13a,14a, 15a,16a,17a	28 ABC	23a
3 ABC	2ab,3a			29 ABC	24a
4 ABC	4a	17 ABC	18a	30 ABC	25b
5 ABC	28a	18 ABC	19a	31 ABC	26a
6,12 ABC	7a	19,27 ABC	20a	32 ABC	8a,17a,24a,26a,27a, 29b
7 ABC	2a	20,26 ABC	21a		
8 ABC	5ac	21 ABC	22a	33 ABC	3a
9,10,11 ANC	6a	22 ABC	3a	34 ABC	15a
13 ABC	8a,9ac,10ac	23,24 ABC	11a		

Contributors: (a) Barker, S. B. (b) Elliott, K. A. C. (c) Quastel, J. H., and Scholefield, P. G.

References: (1) Warburg, O., and Kubowitz, F., Biochem. Ztschr. 189:242, 1927. (2) Elliott, K. A. C., J. Neurophysiol. 11:473, 1948. (3) Craig, F. N., and Beecher, H. K., J. Neurophysiol. 6:135, 1943. (4) Himwich, H. E., and Fazekas, J. F., Am. J. Physiol. 132:454, 1941. (5) Ogata, Y., Jap. J. Med. Sci. Trans. III Biophysics 2:131, 1932. (6) Flexner, J. B., Flexner, L. B., and Strauss, W. L., Jr., J. Cell. Compar. Physiol. 18:355, 1941. (7) Edson, N. L., and Leloir, L. F., Biochem. J. 30:2319, 1936. (8) Dickens, F., and Greville, G. D., Biochem. J. 27:832, 1933. (9) Ebina, T., Tohoku J. Exper. Med. 13:424, 1929. (10) Krebs, H. A., and Rosenhagen, H., Ztschr. f. d. ges. Neurol. u. Psychiat. 134:643, 1931. (11) Chester, A., and Himwich, H. E., Am. J. Physiol. 141:513, 1944. (12) Dickens, F., and Greville, G. D., Biochem. J. 27:832, 1933. (13) Dickens, F., and Simer, F., Biochem. J. 24:1301, 1920. (14) Elliott, K. A. C., Greig, M. E., and Benoy, M. P., Biochem. J. 31:1003, 1937. (15) Loebell, R. O., Biochem. Ztschr. 161:219, 1925. (16) Meyerhof, O. and Lohmann, K., Biochem. Ztschr. 171:381,421, 1926. (17) Warburg, O., Posener, K., and Negelein, E., Biochem. Ztschr. 152:309, 1924. (18) Fujita, A., Biochem. Ztschr. 197:175, 1928. (19) Tobias, J. M., Clark, D. B., and Gerard, R. W., Fed. Proc. 1:85, 1942. (20) Holmes, E. G., Biochem. J. 26:2005, 1932. (21) Pearce, J., and Gerard, R. W., Am. J. Physiol. 136:49, 1942. (22) Roberts, S., and Rock, M., (unpublished). (23) Sellei, C., Weinstein, P., and Jány, J., Biochem. Ztschr. 247:146, 1932. (24) Negelein, E., Biochem, Ztschr. 165:122, 1925. (25) Grieg, M. E., Munro, M. P., and Elliott, K. A. C., Biochem. J. 33:443, 1939. (26) Laser, H., Biochem. J. 31:1671, 1937. (27) Robbie, W. A., and Leinfelder, P. J., Am. J. Opth. 32:208, 1949. (28) Weil-Malherbe, H., Biochem. J. 32:2257, 1938. (29) Elliott, K. A. C., and Baker, Z., Biochem. J. 29:2433, 1935.

Reviewers: Barker, S. B., Dickens, F., Elliott, K. A. C., Jandorf, B. J., Krebs, H. A., Quastel, J. H.; Scholefield, P. G.

133. OXYGEN CONSUMPTION, NERVE TISSUE: DOG

Data Coordinates and Footnotes	Contributors and References
Beadnote	2a,3a,4a,
1-7 ABCDE	1b,2a
Fn 2	3a,4a

Contributors: (a) Elliott, K. A. C. (b) Himwich, H. E.

References: (1) Himwich, H. E., Brain metabolism and cerebral disorders, Baltimore: Williams & Wilkins Co., 1951, Table 17. (2) Himwich, H. E., and Fazekas, J. F., Am. J. Physiol., 132:454, 1941. (3) Elliott, K. A. C., and Henderson, N., J. Neurophysiol., 11:473, 1948. (4) Krebs, H. A., Biochem. et Biophys. Acta., 4:249, 1950.

Reviewers: Barker, S. B.; Craig, F. N.; Elliott, K. A. C.; Fuhrman, F. A.; Himwich, H. E.; Jandorf, B. J.; Krebs, H. A.; Schaefer, A. E.; Tyler, D. B.

134. ANAEROBIC GLYCOLYSIS, NERVE TISSUE: CAT, DOG

Data Coordinates and Footnotes	Contributors and References
Fn 1	b
Fn 2	a
1-7 ABCDEFGH	1b

Contributors: (a) Elliott, K. A. C. (b) Himwich, H. E.

Reference: (1) Chester, A., and Himwich, H. E., Am. J. Physiol. 142:544, 1944.

Reviewers: Craig, F. N.; Elliott, K. A. C.; Fuhrman, F.; Himwich, H. E.; Lardy, H. A.; Summerson, W. H.; Tyler, D. B.

135. OXYGEN CONSUMPTION: REPRODUCTIVE TISSUES, INCLUDING GONADS AND SPERM

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2,3 ABC	1a	12 ABC	6a	22 ABC	8ad
4,24 ABC	2a	13,14,17,18 ABC	7a	23 ABC	9a,10a,11a,12a,13b
5,6,26 ABC	3a	15 ABC	18c		13a,14a,15a
7-10 ABC	4a	16,19,20 ABC	17c	25,27,28 ABC	16a
11 ABC	5a	21 ABC	2ad		

Contributors: (a) Barker, S. B. (b) Elliott, K.A.C. (c) Jandorf, B. J. (d) Quastel, J. H., and Scholefield, P. G.

References: (1) Folley, S. J., and French, T. H., Biochem. J. 45:270, 1949. (2) Fujita, A., Biochem. Ztschr. 197:175, 1928. (3) Barker, S. B., and Schwartz, H. S., (unpublished). (4) Levey, H. A., and Szego, C. M., (unpublished). (5) Macleod, J., Am. J. Physiol. 138:512, 1943. (6) Lardy, H. A., and Phillips, P. H., J. Biol. Chem. 148:333, 1943. (7) Redenz, E., Biochem. Ztschr. 257:234, 1933. (8) Ebina, T., Tohoku J. Exper. Med. 13:424, 1929. (9) Barker, S. B., and Klitgaard, H. M., Am. J. Physiol. 170:81, 1952. (10) Dickens, F., and Greville, G. D., Biochem. J. 27:832, 1933. (11) Dickens, F., and Simer, F., Biochem. J. 35:7, 1941. (12) Edson, N. L., and Leloir, L. F., Biochem, J. 30:2319, 1936. (13) Elliott, K. A. C., Greig, M. E., and Benoy, M. P., Biochem. J. 31:1003, 1937. (14) Warburg, O., Posener, K., and Negelein, E., Biochem. Ztschr. 152:309. 1924. (15) Weil-Malherbe, H., Biochem. J. 32:2257, 1938. (16) Roberts, S., and Szego, C. M., J. Biol. Chem. (in press). (17) Lardy, H. A., and Phillips, P. H., Am. J. Physiol. 138:741, 1943. (18) Lardy, H. A., Hansen, R. G., and Phillips, P. H., Arch. Biochem. 6:41, 1945.

Reviewers: Barker, S. B., Dickens, F., Elliott, K. A. C., Jandorf, B. J., Krebs, H. A., MacLeod, J., Quastel, J. H.; Scholefield, P. G.

136. OXYGEN CONSUMPTION: REPRODUCTIVE TISSUES, PLACENTA, MEMBRANES, AND EMBRYO

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 ABC	1a	7,8 ABC	6a	12 ABC	4a,10a
3,15,16,18 ABC	2a	9 ABC	8ab	13 ABC	11ab
4,5 ABC	3a	10 ABC	4a	14 ABC	11a
6 ABC	4a,5a,6a,7a	11 ABC	9ab	17 ABC	12a

Contributors: (a) Barker, S. B. (b) Quastel, J. H., and Scholefield, P. G.

References: (1) Laser, H., Biochem. J. 31:1671, 1937. (2) Bell, W. B., Brooks, J., and Jowett, M., J. Cancer Res. 12:369, 1928. (3) Kumanomido, S., Biochem. Ztschr. 193:315, 1928. (4) Dickens, F., and Greville, G. D., Biochem. J. 27:832, 1933. (5) Grieg, M. E., Munro, M. P., and Elliott, K. A. C., Biochem. J. 33:443, 1939. (6) Needham, J., Proc. R. Soc., B. 110:46, 1932. (7) Warburg, O., Posener, K., and Negelein, E., Biochem. Ztschr. 152:309, 1924. (8) Weil-Malherbe, H., Biochem. J. 32:2257, 1938. (9) Negelein, E., Biochem. Ztschr. 165:122, 1925. (10) Kleiber, M., Cole, H. H., and Smith, A. H., J. Cell. Compar. Physiol. 22:167, 1943. (11) Fujita, A., Biochem. Ztschr. 197:175, 1928. (12) Murphy, J. B., and Hawkins, J. A., J. Gen. Physiol. 8:115, 1925.

Reviewers: Barker, S. B.; Dickens, F.; Elliott, K. A. C.; Flexner, L. B.; Jandorf, B. J.; Kleiber, M.; Krebs, H. A.; MacLeod J.; Moore, R. O.; Quastel, J. H.; Scholefield, P. G.

137. CORRELATION OF OXYGEN CONSUMPTION WITH BODY SIZE: INVERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B-E	12h	11 B-D & Fn 2	1a	20 B-D & Fn 2,7,8	11a
2 B-E & Fn 2	1a	12 B-D & Fn 2	6a	23 B-D & Fn 3	7a
3 B-D & Fn 3	2a	13 B-E & Fn 2	5a	24 B-D & Fn 3	3a
4 B-D & Fn 4	3a	14 B-E & Fn 2	1a	25 B-E & Fn 3	9a
5 B-D & Fn 3	4a	15 B-D & Fn 3	13a	26 B-D & Fn 3	8a
7 B-E & Fn 4,5,6	1a	16 B-E & Fn 3	13a	27 B-E & Fn 4	9a
9 B-E & Fn 4	5a	17 B-E & Fn 3	3a	28 B-E & Fn 4	1a
10 B-D & Fn 2	6a	18,19 B-E & Fn 2,3	9a	29 B-E & Fn 4	10a

Contributors: (a) von Bertalanffy, L. (b) Macfadyen, A.

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Reviewers: Fry. F. E. J.; Krüger, F.; Macfadyen, A.; von Bertalanffy, L.; Weymouth, F. W.; Zeuthen, E.

138. OXYGEN CONSUMPTION: ENDOPARASITIC HELMINTHS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BCD	1a	14,15,16 BCD	7a	26 BCD	1a
2-4 BCD	2a	17 BCD	1a	27 BCD	9a
5 BCD	3a	18-22 BCD	7a	28 BCD	10a
6,7 BCD	4a	23 BCD	8a	29 BCD	10a,11a
8-10 BCD	5a	24 BCD	1a	30,31 BCD	12a
11 BCD	6a	25 BCD	7a	32 BCD	7a
12,13 BCD	1a				

Contributor: (a) Silverman, M.

References: (1) Lazarus, M., Australian J. Sci. Res. B3:245, 1950. (2) Bueding, E., J. Gen. Physiol. 33:475, 1950. (3) van Grembergen, G., Enzymolgia 13:241, 1949. (4) Friedheim, E. A. H., and Baer, J. G., Biochem. Z. 265:329, 1933. (5) Alt, H. L., and Tischer, O. A., Proc. Soc. Exptl. Biol. Med. 29:222, 1931. (6) Stannard, J. N., McCoy, O. R., and Latchford, W. B., Am. J. Hyg. 27:666, 1938. (7) Rogers, W. P., Parasitology 39:105, 1948. (8) von Brand, T., Biol. Bull. 82:1, 1942. (9) Laser, H., Biochem. J. 38:333, 1944. (10) Adam, W., Z. vergleich. Physiol. 16:229, 1932. (11) von Brand, T., Z. Vergleich. Physiol. 21:220, 1934. (12) Kreuger, F., Zool. Jahrb. Abt. allgem. Zool. 57:1, 1936.

Reviewers: Novelli, G. D.; Paretsky, D.; Pedlow, J. T.; Silverman, M.; von Brand, T.

139. OXYGEN CONSUMPTION: PARASITIC PROTOZOA

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1-3 BCD	1b	9 BCD	3a,9b	18 BCD	3a,12b
4 BCD	2b,3b,4b	10 BCD	3a,4b,10b	19 BCD	9b
5 BCD	3ab,4b	11-14 BCD	9b	20 BCD	3a,9b
6 BCD	2b,3b,4h,5b	15 BCD	3a,11b	21 BCD	13b
7 BCD	3a	16 BCD	9a	22 BCD	14b
8 BCD	7b,8b	17 BCD	3a,9b	23-29 BCD	15b

Contributors: (a) Chang, S. L. (b) Silverman, M.

References: (1) Lwoff, A., Zentr. Bakt. Parasitenk. Abt. I. Orig. 130:498, 1934. (2) Adler, S., and Ashbel, R., Arch. zool., ital. 20:521, 1934. (3) von Brand, T., and Johnson, E. M., J. Cellular Comp. Physiol. 29:33, 1947. (4) Chang, S. L., J. Infect. Dis. 82:109, 1948. (5) Fulton, J. D., and Joyner, L. P., Trans. Roy. Soc. Trop. Med. Hyg. 43:273, 1949. (6) Reiner, L., Smythe, C. V., and Pedlow, J. T., J. Biol. Chem. 113:75, 1936. (7) Moulder, J. W., Science 106:168, 1947. (8) Moulder, J. W., J. Infect. Dis. 83:42, 1948. (9) von Brand, T., Tobie, E. J., and Mehlman, B., J. Cellular Comp. Physiol. 35:273, 1950. (10) von Brand, T., Johnson, E. M., and Rees, C. W., J. Gen. Physiol. 30:163, 1946. (11) Harvey, S. C., J. Biol. Chem. 179:435, 1949. (12) Christophers, S. R., and Fulton, J. D., Ann. Trop. Med. Parasitol. 82:43, 1938. (13) Riedmueller, L., Zentr. Bakt. Parasitenk. Abt. I. Orig. 137:428, 1936. (14) Williams, R. Massart, L., and Peeters, G., Naturwissenschaften 30:169, 1942. (15) Maier, J., and Coggeshall, L. T., J. Infect. Dis. 69:87, 1941.

Reviewers: Chang, S. L.; Novelli, G. D.; Paretsky, D.; Pedlow, J. T.; Silverman, M.; von Brand, T.

140. RATES OF RESPIRATION: LEAVES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BCD	1c	8 BD	7a	17 BCD	16c
Fn 2	2c	9 BC	6d	18 BD	17b
2 BCD	3c	10 BC	10b	19 BC	18c
3 BD	4c	Fn 7	11a	20 BC	4b
4 BD & Fn 3	5abc	11 BC & Fn 8	12a	21 BC	19b
5 BD & Fn 4	21c	12 BD	9bc	22 BD	20c
6 BC	7a	13 BC & Fn 9	7a	23 BC	6b
7 BD	9c	14 BCD & Fn 10	13c	1,2,14,17 E	Calc. fr col. C, D & Fn 1
Fn 6	6b	15 BD	14b		
		16 BC	15c		

Contributors: (a) Fidler, J. C. (b) Klein, R. M. (c) Lyon, C. J. (d) Thomas, M.

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141. RATES OF RESPIRATION: ROOTS, RHIZOMES, TUBERS, BULBS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BC & Fn 2,3	1a	6 BC	3b	Fn 10	7a
2 BCD	2c	7,8 BC & Fn 7,8	1a	Fn 11	5b
Fn 4,5	1a	9 B D & Fn 9	c	14 BC & Fn 12	1a
3 B D & Fn 6	9c	10 BC	8b	15 B D & Fn 13	4b
4 B D	10b	11 BC	8c	2,13 E	Calc. fr. Col. C, D & Fn 1
5 BC & Fn 2	11b	12 BC	8b	3 E	12d
		13 BCD	6c		

Contributors: (a) Fidler, J. C. (b) Klein, R. M. (c) Lyon, C. J. (d) Girton, R. E.

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142. RATES OF RESPIRATION: SEEDS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B D	1b	6 B D & Fn 4	5b	10 B D	1b
2 BCD	2c	7 BC & Fn 5	3b	11 C & Fn 3	7b
Fn 2	3b	8 BC	10b	12 BC & Fn 5	3b
3 BC & Fn 3	4b	Fn 6	6a	13 BC & Fn 7	8b
4,5 B D	1b	9 B D	1b	14 BC & Fn 5	3b
				Fn 8,9	9c

Contributors: (a) Fidler, J. C. (b) Klein, R. M. (c) Lyon, C. J.

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/1/ Sherman, H., Bot. Gaz. 72: 1, 1921. /2/ Stoward, F., Ann. Bot. 22: 415, 1908. /3/ Bailey, C. H., Plant Physiol. 15: 257, 1940. /4/ Nicolas, G., Ann Sci. Nat. Bot. 10: 1, 1909. /5/ Pack, D. A., Bot. Gaz. 71: 32, 1920. /6/ Smith, A.J.M., and Gane, R., Report of the food iovestigation board, London: H. M. Stationery Office, 1934. /7/ Levin, M., Deutsch, Bot. Ges. 23: 100, 1905. /8/ Coleman, D. A., et al., U. S. Dept. Agr. Tech. Bull. 100, 1928. /9/ Bonnier, G., and Mangin, L., Ann. des Sci. Nat. Bot. 98: 293, 1884. /10/ Platenius, H., Plant Physiol. 17: 179, 1942.

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143. RATES OF RESPIRATION: FRUITS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B D	1b	5 BCD & Fn 5	5c	11 B D	10b
1 C & Fn 2	1a	6 B D	6b	11 C & Fn 7	9e
2 BCD	2ad	7 BC	7d	12 BCD & Fn 8	11c
3 D	2d	Fn 6	8b	1,2,5,11,12 E	Calc fr col C,D & Fn 1
3 B D & Fn 3	3b	8 B D	6b	4,10 E	4a
Fn 4	3e	9 BC	8b		
4 BC	4b	10 BC	4b		

Contributors: (a) Girton, R. E. (b) Klein, R. M. (c) Lyon, C. J. (d) Thomas, M. (e) Ulrich, R.

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144. RATES OF RESPIRATION: MOSSES, FERNS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2,4 BD	1a	8 BC	5a	14,15 BCD & Fn 7,	
3 BD & Fn 2	2a	9,10 BD & Fn 6,7,8	6a	11,12	7b
5,6 CD & Fn 3,4	3b	11,12 BCD & Fn 7,	7b	5,6,11,12,14,15 E	Calc. fr. Col. C,
7 BC	4a	9,10	7b		D & Fn 1
		13 BC	5a		

Contributors: (a) Klein, R. M. (b) Lyon, C. J.

References: (1) Usami, S., Acta Phytochim. 9:287, 1937. (2) Fraymouth, J., Ann. Bot. 42:75, 1928. (3) Jönsson, B., Compt. Rend. 119:440, 1894. (4) Hartenburg, W., Jahr. Wiss. Bot. 85:641, 1937. (5) Stoker, O., Tab. Biol. 5:671, 1929. (6) Belehrádek, J., and Belehradekova, M., New Phytol. 28:313, 1929. (7) Maige, G., Ann. Sci. Nat. Bot. Series 9, 14:1, 1911.

Reviewers: Blinks, L. R.; Fidler, J. C.; Gaffron, H.; Girton, R. E.; Gustafson, F. G.; Hansen, E.; Lyon, C. J.; Myers, J.; Robertson, R. N.; Smock, R. M.; Thomas, M.; Voth, P. D.

145. RATES OF RESPIRATION: FUNGI, LICHENS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BCD & Fn 3	9b	10,11 BCD	5b	17 BC & Fn 3	9a
Fn 4	9a	Fn 11,12	5bc	18 B D & Fn 5	13a
2 BCD & Fn 5	1b	12 B D & Fn 13	6a	19 B D	9a
3 B D & Fn 5	10a	13 BC & Fn 5	11a	20 B D & Fn 5	8a
4,5 B D & Fn 6,7	2b	14,15 B D & Fn 14,		21 BCD	14b
6 B D & Fn 3	9a	15	7b	22 BC & Fn 3	15a
7 B D & Fn 8	3a	16 B D & Fn 6	12a	1,2,10,22 E	Calc. fr. col. B,
8,9 B D & Fn 9,10	4b				C & Fn 1
				14 E	16c

Contributors: (a) Klein, R. M. (b) Lyon, C. J. (c) Thomas, M.

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146. RATES OF RESPIRATION: ALGAE

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 B D	6b	6 B D & Fn 4	8a	12,14 D & Fn 7	5a
2 B D	7a	7 B D & Fn 2	2b	13 BCD	4b
3 BCD & Fn 2,3	1b	8,9 BCD & Fn 5,6	3b	15,16 B D & Fn 7	5a
4 B D	5a	10 BCD	4b	17 BCD	4b
5 B D	7a	11 B D	7a	3,8,9,10,13,17 E	Calc. fr col C,D
					& Fn 1

Contributors: (a) Klein, R. M. (b) Lyon, C. J.

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/1/ Cramer, M., and Myers, J., Plant Physiol. 24: 255, 1949. /2/ Gaffron, H., J. Gen. Physiol. 28: 259, 1945. /3/ Pal, N. L., New Phytol. 33: 241, 1934. /4/ Hoffman, C., Jahr. Wiss. Bot. 71: 214, 1929. /5/ Stocker, O., Tab. Biol. 5: 683, 1929. /6/ Webster, G. C., and Frenkel, A. W., Plant Physiol. 28: 63, 1953. /7/ Watanabe, A., Acta Phytochim. 6: 315, 1932. /8/ Roas, E., Am. J. Bot. 25: 458, 1938.

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147. OXYGEN CONSUMPTION: BACTERIAL SUSPENSIONS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 BCD	1b	9 BCD	9b	27 BCD	16b
2 BCD	2b,3b	10 BCD	10b	28 BCD	17b
3,4 BCD	4b	11-15 BCD	11b	29 BCD	18b
5 BCD	5b	16-23 BCD	12b	30,31 BCD	19b
6 BCD	6b	24 BCD	13b	Fn 1,2,3	19a
7 BCD	7b	25 BCD	14b	32,33 BCD	9b
8 BCD	2b,8b	26 BCD	15b	34 BCD	20b

Contributors: (a) Pedlow, J. T. (b) Silverman, M.

References: (1) Meyerhof, O., and Burk, D., Z. Physic. Chem. A 139:117, 1928. (2) Ajl, S. J., J. Bact. 59:499, 1950. (3) Ajl, S. J., and Wong, T. O., J. Bact. 61:379, 1951. (4) Nickerson, W. J., and Sherman, F. G., J. Bact. 64:667, 1952. (5) Gary, N. D., and Bard, R. C., J. Bact. 64:501, 1952. (6) Crook, P. G., J. Bact. 63:193, 1952. (7) Levine, S., and Krampitz, L. O., J. Bact. 64:645, 1952. (8) Krebs, H. A., Biochem. J. 31:2095, 1937. (9) Stein, R. M., and Frazier, W. L., J. Bact. 42:501, 1941. (10) Chang, S. C., Silverman, M., and Keresztesy, J. C., J. Bact. 62:753, 1951. (11) Nunheimer, T. D., and Fabian, F. W., J. Bact. 44:215, 1942. (12) Edson, N. L., and Hunter, G. J. E., Biochem. J. 37:563, 1943. (13) Oginsky, E. L., Smith, P. H., and Solotorovsky, M., J. Bact. 59:29, 1950. (14) Bernheim, F., and Bernheim, M. L. C., J. Bact. 46:225, 1943. (15) Sebek, O. K., and Randles, C. I., J. Bact. 63:693, 1952. (16) Seeley, H. W., and Vandermark, P. J., J. Bact. 61:27, 1951. (17) O'Kane, D. J., J. Bact. 60:449, 1950. (18) Gunsalas, I. C., and Umbreit, W. W., J. Bact. 49: 347, 1945. (19) Sevag, M. G., and Shelburne, M., J. Bact. 43:411, 1942. (20) Cochrane, V. W., and Gibbs, M., J. Bact. 61: 305, 1951.

Reviewers: Novelli, G. D.; Paretsky, D.; Pedlow, J. T.; Silverman, M.; von Brand, T.

148. BASAL METABOLISM: MAN

All values: (a) Boothby, W. M., from smoothed curve based on references 1, 2, 3. All ranges: (b) DuBois, E. F., from coefficients of variation for data from reference 2, 3, 4, 5, 6.

References: (1) Boothby, W. M., Berkson, J. and Dunn, H. L., Am. J. Physiol. 116:468, 1936. (2) Robertson, J. D., and Reid, D. D., Lancet 2:940, 1952. (3) Harris, J. A, and Benedict, F. S., Carnegie Inst. of Washington Publ. 279, 1919. (4) Lewis, R. C., Kinsman, G. M., and Iliff, A., Am. J. Dis. Child. 53:348, 1937. (5) Lewis, R. C., Duvall, A. M., and Iliff, A., J. Pediatrics 23: , 1943. (6) Berkson, J. and Boothby, W. M., Am. J. Physiol. 121:669, 1938.

Reviewers: Berkson, J.; Boothby, W. M.; Carpenter, T. M.; DuBois, E. F.

149. COMPARISON OF STANDARDS OF BASAL METABOLISM: MAN

Contributor: (a) DuBois, E. F.

References: (1) Col. B, table 148 of this publication. (2) Col. C, Fleisch, A., Helvetica Med. Acta, 18:23, 1951. (3) Col. D, Robertson, J. D., and Reid, D. D., Lancet, 3:940, 1952. (4) Col. E, Lewis, R. C., Duval, A. M., and Iliff, A., J. Pediatrics, 23:1, 1943. (5) Col. F, Boothby, W. M., Berkson, J., and Dunn, H. L., Am. J. Physiol., 116:468, 1936. Estimate of ordinary range based on coefficient of variation of 6.9% calculated by contributor from data in references: 3, 4, and (6) Berkson, J., and Boothby, W. M., Am. J. Physiol. 121:669, 1938. (7) Harris, J. A., and Benedict, F. S., Carnegie Inst. of Washington Publ. 279, 1919. (8) Lewis, R. C., Kinsman, G. M., and Iliff, A., Am. J. Dis. Child. 53:348, 1937.

Reviewers: Berkson, J.; Boothby, W. M.; Carpenter, T. M.; DuBois, E. F.; Iliff, A.

150. BASAL METABOLISM: VERTEBRATES

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1,2 BC	27a	7 DEF	9a,10a	14 DEF	6a
1 DEF	14a	8 DEF	12a	15 BC	22a
2 DEF	14a,15a	9 DEF	7a	15 DEF	2a
3 B-F	8a	10 B-F	3a	16 BC	26a
4 BC	29a	11 BC	25a	16 DEF	11a
4 DEF	19a,20a	11 DEF	5a	Fn 1	Quoted by a from 3
5 BC	Calc. fr 23 & 24 by a	12 BC	21a		8,21,22,23,24,25, 26,27,28,29
5 DEF	4a	12 DEF	1a		
6-9 BC	Calc. by a	13,14 BC	28a	Fn 3	a
6 DEF	13a	13 DEF	16a,17a,18a		

Contributor: (a) Mitchell, H. H.

References: (1) David, J. E., and Van Dyke, H. B., J. Biol. Chem. 100:455, 1933. (2) Bricker, M. L., and Mitchell, H. H., J. Nutrition 34:491, 1947. (3) Kibler, H. H., Brody, S., and Worstell, D., J. Nutrition 33:331, 1947. (4) Mitchell, H. H., and Haines, W. T., J. Agr. Res. 34:549, 927, 1927. (5) Rakieten, N., J. Nutrition 10:357, 1935. (6) Lee, M. O., J. Nutrition 18:489, 1939. (7) Benedict, F. G., and Lee, M. O., Carnegie Inst. Wash. Publ. 489, 1937. (8) Bruhn, J. M., Am. J. Physiol. 110:477, 1934. (9) Galvao, P. E., Am. J. Physiol. 148:478, 1947. (10) Kunde, M. M., and Steinhaus, A. H., Am. J. Physiol. 78:127, 1926. (11) Blaxter, K. L., J. Agr. Sci. 38:207, 1948. (12) Ritzman, E. G., Washburn, L. E., and Benedict, F. G., N. H. Agr. Exp. Sta. Tech. Bull. 66, 1936. (13) Bruhn, J. M., and Benedict, F. G., Proc. Am. Acad. Arts and Sci. 71:259, 1936. (14) Harris, J. A., and Benedict, F. G., Carnegie Inst. Wash. Bull. 279, 1919. (15) McCrery, J., Lamb, M. W., and Bavousett, N. D., J. Nutrition 25:245, 1943. (16) Capstick, J. W., and Wood, T. B., J. Agr. Sci. 12:257, 1922. (17) Deighton, T., J. Agr. Sci. 19:140, 1929. (18) Breirem, K., Tierernährung, 8:463, 1936. (19) Forbes, E. H., et al., J. Agr. Res. 33:591, 1926. (20) Ibid., 43:1003, 1931. (21) Smuts, D. B., Pflüger's Arch. ges Physiol. 232:105, 1933. (22) Lee, M. O., Am. J. Physiol. 79:24, 1929. (23) Meeh, K., Z. Biol. 15:425, 1879. (24) Mitchell, H. H., Card, L. E., and Hamilton, T. S., Ill. Agr. Exp. Sta. Bull. 278, 1926. (25) Lee, M. O., and Fox, E. L., Am. J. Physiol. 106:91, 1933. (26) Mitchell, H. H., Ill. Agr. Exp. Sta. Ann. Rept. 1927, p155. (27) DuBois, D., and DuBois, E. F., Arch. Int. Med., 17:863, 1916. (28) Brody, A., Comfort, J. E., and Matthews, J. S., Mo. Agr. Exp. Sta. Res. Bull. 115, 1928. (29) Moulton, C. R., J. Biol. Chem. 24:299, 1916.

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151. BASAL AND RESTING ENERGY METABOLISM: BEEF CATTLE

References: Values calculated and adapted from Brody, S., Comfort, J. E., Kibler, H. H., and Worstell, D. M., Mo. Agr. Exp. Sta. Res. Bull. 404 and 115; and contributed by Brody, S.

Reviewers: Brody, S.; Colovos, N. F.; Mitchell, H. H.; Ritzman, E. G.; Winchester, C. F.

152. RESTING ENERGY METABOLISM: DAIRY CATTLE

References: Values calculated and adapted from the data in Brody, S., Kibler, H. H., and Ragsdale, A. C., Mo. Agr. Exp. Sts. Res. Bull. 335 and 350; and contributed by Brody, S.

Reviewers: Brody, S.; Colovos, N. F.; Kibler, H. H.; Mitchell, H. H.; Ritzman, E. G.; Winchester, C. F.

153. RESTING ENERGY METABOLISM: GOATS

Reference: Contributed and adapted from Brody, S., Rec. Bull. 291, Univ. of Missouri, Agr. Exp. Sta., 1938.

Reviewers: Brody, S.; Carpenter, T. M.; Colovos, N. F.; Mitchell, H. H.; Winchester, C. F.

154. BASAL AND RESTING ENERGY METABOLISM: GUINEA PIGS

References: Values calculated and adapted from the data in Kibler, H. H., and Brody, S., J. Nutrition 33:331, 1947. Reprint contributed by Brody, S., and tabular data contributed by Kibler, H. H.

Reviewers: Brody, S.; Colovos, N. F.; Kibler, H. H.; Mitchell, H. H.; Winchester, C. F.

155. RESTING ENERGY METABOLISM: HORSES

References: Values calculated and adapted from the data in Brody, S., Kibler, H. H., and Trowbridge, E. A., Mo. Agr. Exp. Sta. Res. Bull. 368, and contributed by Brody, S.

Reviewers: Brody, S.; Colovos, N. F.; Kibler, H. H.; Mitchell, H. H.; Winchester, C. F.

156. RESTING ENERGY METABOLISM: MULES

References: Values calculated and adapted from the data in Kibler, H. H., and Brody, S., Mo. Agr. Exp. Sta. Res. Bull. 438. Data contributed by Brody, S. Headnote from Brody S., Kibler, H. H., and Trowbridge, E. A., Mo. Agr. Exp. Sta. Res. Bull. 368, 1943.

Reviewers: Brody, S.; Kibler, H. H.; Mitchell, H. H.; Winchester, C. F.

157. BASAL AND RESTING ENERGY METABOLISM: RATS

References: Values calculated and adapted from Kibler, H. H., and Brody, S., J. Nutrition 24:461, 1942. Reprint contributed by Brody, S., and tabular data contributed by Kibler, H. H.

Reviewers: Brody, S.; Colovos, N. F.; Kibler, H. H.; Mitchell, H. H.; Winchester, C. F.

158. RESTING AND FASTING ENERGY METABOLISM: SWINE

References: Values calculated and adapted from the data in Brody, S., and Kibler, H. H., Mo. Agr. Exp. Sta. Res. Bull. 380. Data contributed by Brody, S.

Reviewers: Brody, S.; Colovos, N. F.; Kibler, H. H.; Mitchell, H. H.; Winchester, C. F.

159. RESTING AND FASTING ENERGY METABOLISM: CHICKENS

References: Values calculated and adapted from the data in Kibler, H. H., and Brody, S., J. Nutrition 28:27, 1944. Reprint contributed by Brody, S.

Reviewers: Brody, S.; Kibler, H. H.; Landauer, W.; Mitchell, H. H.; Winchester, C. F.

160. METABOLIC RATES: SOIL ORGANISMS

Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References	Data Coordinates and Footnotes	Contributors and References
1 IJ	Calc. by b from 14	12 IJ	5a	25 IJ	10a
1,8 K	a	12 K	a	25 K	a
2,4,5 B-G	1a	13,14 B-G	6a	26 B-G	5a
2 H	1a	15 B-G	5a	27 IJ	11a
3 J	Calc. by b from 14	16 IJ	2a	27 K	a
4,5,7,9-11,13-15, 17,18,21,22,24, 26,30-33,35,36 H	a	16 K	a	28 H-G	5a
		17,18 B-G	7a	29,34 J	4a
		19 K	a	29,34,37 K	a
6 IJ	2a	19 J	4a	30,31,32,33,35, 36,38,39 B-G	5a
6 K	a	20 IJ	9a,12a	37 I	a
7 B-G	3a	21,22,24 B-G	8a	38 J	2a
8 IJ	4a	23 IJ	9a,12a	Fn 1	13a
9,10,11 B-H	4a	23 K	a		

Contributors: (a) Macfadyen, A. (b) Nielsen, L. O.

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